



# VOLUME I



# **SoftCard™**

**A Peripheral for the Apple II®  
With CP/M® and Microsoft BASIC on diskette.**

**Produced by Microsoft**

**Microsoft Consumer Products  
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# Introduction



# The SoftCard Explained

## The Circuit Card

The Microsoft SoftCard is a plug-in card for the Apple II microcomputer modification, but be sure to read the Installation and Operation Manual to ensure that you do it correctly.

Once you have installed the SoftCard, you will be able to operate your Apple in either 6502 or Z-80 mode, using software commands to switch between the two. Whenever you are in 6502 mode, the SoftCard in no way affects operation of your Apple.

When in Z-80 mode, you can run both the CP/M operating system from Digital Research and Microsoft's BASIC interpreter, Version 5.0, which are included in the SoftCard package.

The SoftCard is easy to install and requires no hardware or software puter that greatly enhances the software capability of the Apple. The SoftCard actually contains a Z-80A microprocessor, allowing the Apple to run software that was written for Z-80 based microcomputers.

## CP/M Operating System

Next to the circuit card itself, CP/M is the most important key to allowing a wide variety of Z-80 software to run on the Apple. Version 2.2 of CP/M is included in the SoftCard package.

CP/M (which stands for Control Program/Microprocessors) is an operating system designed for use with 8080 and Z-80 microprocessors. It is composed of many small programs whose collective function is to write information to, and retrieve information from, microcomputer floppy disks. CP/M has been adapted to run on almost all computers using the 8080 or Z-80 families of microprocessors and because of its widespread use, a very large group of high-level languages and application software has been written to operate in the CP/M environment.

With the advent of the SoftCard, Apple owners are now able to take advantage of the CP/M Operating System. Microsoft has implemented CP/M on the Apple II, making all modifications needed to make CP/M run on the Apple.

Standard CP/M programs will be compatible with Apple CP/M. There is just one difficulty in loading them on the Apple: Apple disks have a physically different format than CP/M disks. Before a CP/M program written for another type of computer can be run on the Apple, it must be downloaded from a standard CP/M system to the Apple. This process is described *in detail* in the Software Utilities Manual.

In addition to supporting a wider variety of software, CP/M offers several convenient features not found in Apple DOS. These include easy interface to machine language programs; faster disk I/O; simple file transfer; and wild card file-naming conventions that allow you to refer to multiple files with one name.

## **Microsoft BASIC**

Microsoft's ANSI-standard BASIC interpreter, in its fifth major release, is also included as part of the SoftCard package. Microsoft BASIC has many features not found in Applesoft. Among these are PRINT USING, CALL, WHILE/WEND, CHAIN and COMMON and built-in Disk I/O statements. In addition, most of the graphics features of Applesoft have been incorporated into Microsoft BASIC to take advantage of the Apple's special capabilities. A complete list of the differences between Microsoft BASIC and Applesoft can be found in Part 4, the Microsoft BASIC Reference Manual.

## **The Diskettes**

Two diskettes, each containing CP/M and Microsoft BASIC plus several utility programs, are provided. One of the disks is in 13-Sector format and should be used if you don't have a Language Card or DOS 3.3. The other disk is in 16-Sector format and should be used with systems that have the Apple Language Card and/or DOS 3.3. The 16-Sector disk also contains an enhanced version of Microsoft BASIC with high-resolution graphics capabilities.

# Designers and Manufacturer

## The Softcard Circuit Board

**Designer:** The SoftCard circuit board was designed by Don Burtis of Burtronix, Villa Park, California. Microsoft Consumer Products is grateful to Burtronix for its contribution to making the SoftCard a reality.

**Manufacturer:** The SoftCard circuit board is manufactured for Microsoft Consumer Products by Vista Computer Co. of Santa Ana, California.

## SoftCard Software

The CP/M operating system, Version 2.0, is licensed by Microsoft from Digital Research, Inc., of Pacific Grove, California. The BASIC interpreter included in this package is Microsoft's ANSI-standard BASIC-80, Version 5.0, with additional enhancements to take advantage of the Apple's special capabilities. Neil Konzen, of Microsoft Consumer Products, was instrumental in implementing all of the SoftCard software on the Apple II.

# System Requirements

The SoftCard will operate on an Apple II or Apple II Plus microcomputer with a minimum of 48K RAM and one disk drive.

The SoftCard supports the Apple Language Card system and can utilize 12K of the 16K RAM on the Language Card when in Z-80 mode.

CP/M occupies 7K of RAM, only 5K of which is needed during the execution of user programs. CP/M and MBASIC together occupy just over 29K RAM. CP/M and GBASIC (BASIC with high-resolution graphics, found only on the 16-Sector disk) occupy just over 37K RAM.

When you are in 6502 mode, the SoftCard in no way affects operation of the Apple II.

When in Z-80 mode, all standard Apple I/O peripheral cards and some independent peripherals are supported.



# SoftCard Terminology

There are several terms we use throughout this documentation that you may not understand at first glance. These terms, their definitions, and the reasons we have adopted them are listed below.

## **44K System**

Refers to an Apple II or Apple II Plus that has 48K RAM installed. We call it a 44K System, because when you are using the SoftCard (in Z-80 mode), you can address 44K of the 48K total. The 4K you lose is used to handle the Apple screen and CP/M sector read and write routines.

## **56K System**

Refers to an Apple II or Apple II Plus *with* Language Card (an Apple with 64K RAM installed). As with a 48K system, 4K of the 64K is dedicated to the Apple screen and CP/M sector read and write routines. And since only 12K of the 16K RAM on the Language Card is addressable, you have, in effect, a 56K system.

## **13-Sector Disk**

Refers to one of the disks in the SoftCard package. This disk should be used if you have Apple DOS 3.2 or earlier and no Language Card.

## **16-Sector Disk**

Refers to the other disk in the SoftCard package. This disk should be used if you have an Apple Language Card or DOS 3.3. In addition to all of the software on the 13-Sector disk, the 16-Sector disk includes a second version of BASIC, called GBASIC, that includes high-resolution graphics features.

## **A:-F:**

The names A:, B:, C:, D:, E: and F: refer to disk drives. This is the standard CP/M drive naming convention and since we are using CP/M, it is used throughout this manual. For the relationship of drive names to drives, see the Installation and Operations Manual.

**External Terminal**

Refers to two types of devices. An external terminal can be a  $24 \times 80$  character video card (such as the Videx Videoterm), or it can actually be a second terminal (such as a Hazeltine or SOROC) that you are using with your system.

**RETURN vs.  $\langle cr \rangle$  vs. carriage return**

All of these mean to press the RETURN key on the Apple keyboard.

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## **Service Information**

If your SoftCard requires repair, please return it to the dealer from whom it was purchased. If it is not possible to return the SoftCard to your dealer, you may send it directly to Microsoft Consumer Products.

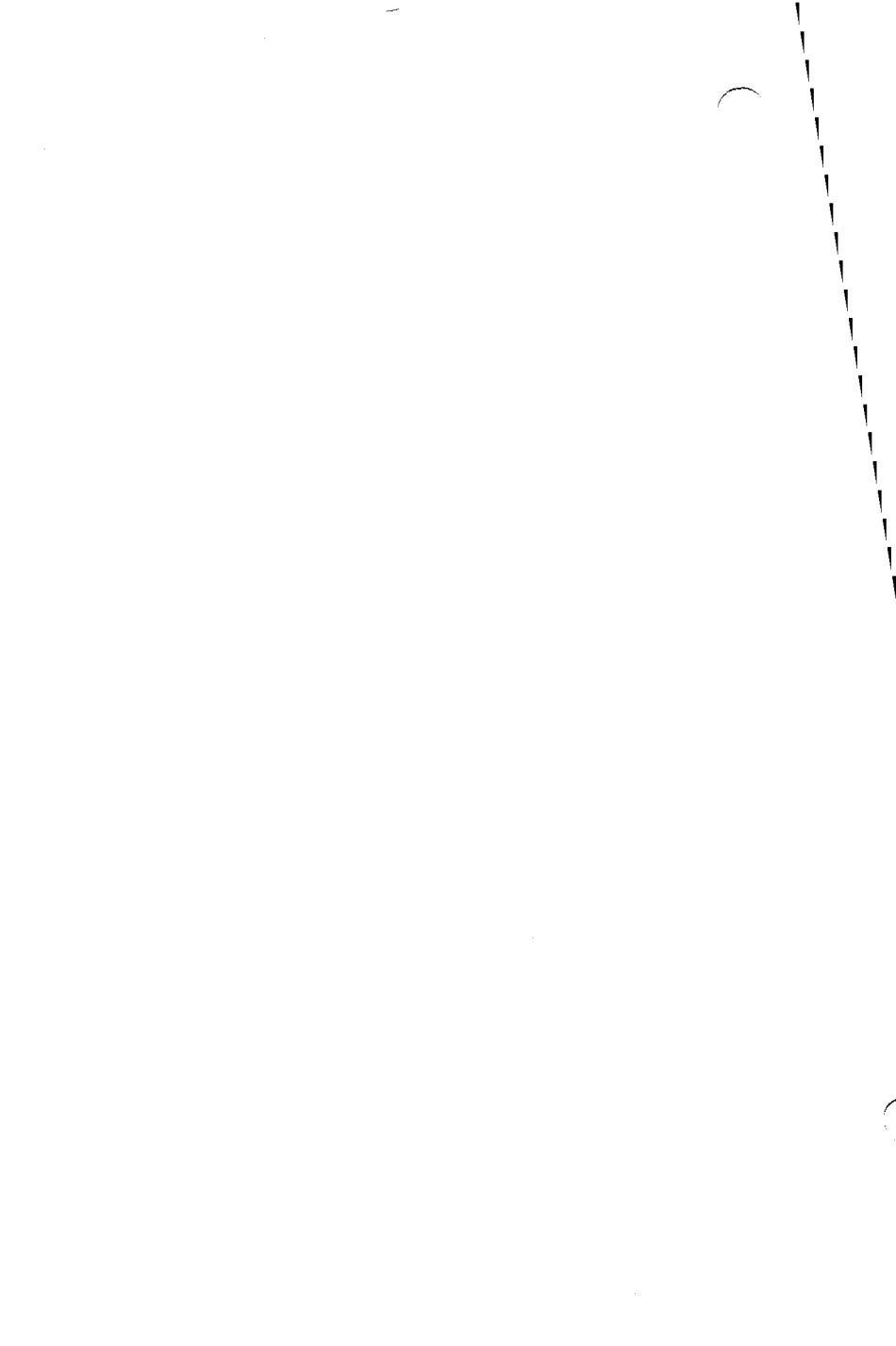
If the repair is required during the warranty period, please enclose proof of purchase. During warranty, we will replace or repair your SoftCard without charge. See page I-10 for more details regarding warranty coverage.

If the SoftCard requires service after the warranty period expires, it will be repaired for a flat fee of \$39.50. This service charge does not cover damage due to negligence, misuse or inadequate packaging on return to MCP.

To return your SoftCard for service, please mail it post-paid to Microsoft Consumer Products. Package the card securely as we cannot be responsible for damage due to shipping. BE SURE to enclose proof of purchase for warranty work or a check or money order in the amount of \$39.50 for non-warranty repairs.

Mail post-paid to:

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400 108th Ave. NE, Suite 200  
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# **SoftCard Installation and Operations**



# **PART I: INSTALLATION AND OPERATION**

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# **Chapter 1**

## **How To Install the SoftCard**

- **Apple Peripheral Cards: What Goes Where**
- **Interface Cards Compatible with CP/M**
- **Placement of Apple Disk Drives**
- **Printer Interface Installation**
- **General Purpose I/O Installation**
- **Using an External Terminal Interface**
- **Installation of the SoftCard**

Installation of the SoftCard is easy, but there are some things you should know before you install it. Improper installation can damage both the SoftCard and the rest of your Apple system. So . . .

**READ THESE INSTRUCTIONS CAREFULLY BEFORE  
INSTALLING THE SOFTCARD!!**

## **Apple Peripheral Cards: What Goes Where**

Before you install the SoftCard, you must make sure that your other peripheral cards are installed in the correct peripheral slots in your Apple to insure proper operation with Apple CP/M.

This is necessary because unlike Applesoft and Integer BASIC (but similar to Apple PASCAL), Apple CP/M requires that peripheral I/O cards be plugged into specific slots depending on their intended use. For instance, if you have a printer interface, it should be installed in slot one. This allows you to refer to the printer without specifying a slot number, as is necessary with Applesoft and Integer BASIC. Use the information below as a guide for installing any other peripheral interface cards you might own.

**NOTE to Apple Language Card users:**

The peripheral card slot assignments for Apple CP/M are exactly the same as for Apple Pascal. Therefore, if you have your system set up for use with Apple Pascal, no rearrangement is necessary.

## **Interface Cards Directly Compatible With CP/M:**

Below is a list of the I/O peripheral card types that are known to be directly compatible with Apple CP/M. The cards listed below, when installed in the appropriate Apple peripheral slot, will work without any software modifications.

| <b>TYPE</b> | <b>CARD NAME</b>                                                                                                                                                            |
|-------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 1           | Apple Disk II Controller                                                                                                                                                    |
| *2          | Apple Communications Interface<br>California Computer Systems 7710A Serial Interface                                                                                        |
| 3           | Apple High Speed Serial Interface<br>Apple Silentype Printer Interface<br>Videx Videoterm 24×80 Video Terminal Card<br>M&R Enterprises Sup-R-Term 24×80 Video Terminal Card |
| 4           | Apple Parallel Printer Card                                                                                                                                                 |

\*The CCS 7710A serial interface card is the preferred card of type 2 as it supports hardware handshaking and variable baud rates from 110-19200 baud. The Apple Communications Interface card requires hardware modification for use with data rates other than 110 or 300 baud.

There are some interface cards not listed above that may work with Apple CP/M. As a general rule, any card that is directly compatible with Apple Pascal without requiring any software modifications will probably be directly compatible with Apple CP/M as well. Other peripheral cards may be used if software supplied by the card manufacturer is bound to your Apple CP/M system using the CONFIGIO program. See the Software Details section and the CONFIGIO utility for more information on the implementation of non-standard peripheral cards.

Below is a table of the assigned functions for each of the Apple slots, along with the card types (see above) that are recognized when installed in each. Unless otherwise noted below, unrecognized cards or empty slots are ignored.

**IMPORTANT:** MAKE SURE your Apple is TURNED OFF before you attempt to rearrange your peripheral cards or serious damage may result to your Apple.

| SLOT | VALID CARD TYPES                 | PURPOSE                                                                                                              |
|------|----------------------------------|----------------------------------------------------------------------------------------------------------------------|
| 0    | Not used for I/O                 | This slot may contain a Language Card or an Applesoft or Integer BASIC ROM card. (The latter are not used by CP/M.)  |
| 1    | types 2,3,4                      | Line printer interface (CP/M LST: device)                                                                            |
| 2    | input: 2, 3,4<br>output: 1,2,3,4 | General purpose I/O (CP/M PUN: and RDR: devices)                                                                     |
| 3    | types 2,3,4                      | Console output device (CRT: or TTY:) The normal Apple 24×40 screen is used as the TTY: device if no card is present. |
| 4    | type 1                           | Disk controller for drives E: and F:. The SoftCard may be installed here if not occupied by a Disk controller card.  |
| 5    | type 1                           | Disk controller for drives C: and D:.                                                                                |

| <b>SLOT</b> | <b>VALID CARD TYPES</b> | <b>PURPOSE</b>                                                |
|-------------|-------------------------|---------------------------------------------------------------|
| 6           | type 1                  | Disk controller for drives A: and B:. (must be present)       |
| 7           | any type                | No assigned purpose. The SoftCard may be installed in slot 7. |

## Placement of Apple Disk Drives

As indicated in the table above, Apple Disk II controller cards may be installed in slots 6, 5 or 4. You must have at least one disk drive installed in slot six. Disk controller cards are installed in order downward from slot 6, i.e., your second controller should be installed in slot 5, and the third in slot 4.

In CP/M, each of the drives is assigned a letter name, followed by a colon. For instance, the disk in slot 6, drive 1, is CP/M drive A:. (See table below.) This is the way we will refer to your disk drives throughout this documentation. You may want to label each disk drive according to its assigned CP/M name and it is for just that purpose that we enclosed the package of self-adhesive disk drive labels.

|            | <b>CP/M name</b> | <b>Slot #</b> | <b>Drive #</b> |
|------------|------------------|---------------|----------------|
| 1st drive: | A:               | 6             | 1              |
| 2nd drive: | B:               | 6             | 2              |
| 3rd drive: | C:               | 5             | 1              |
| 4th drive: | D:               | 5             | 2              |
| 5th drive: | E:               | 4             | 1              |
| 6th drive: | F:               | 4             | 2              |

### NOTE for DOS 3.3 or Apple Pascal users:

Apple CP/M supports the large-capacity 16-Sector disk format used by DOS 3.3 and Apple Pascal, in addition to standard Apple II 13-Sector format.

## Printer Interface Installation

If you own a printer, its interface card must be installed into slot 1. Most interface cards designed to work with Apple Pascal will work with Apple CP/M as well.



# General Purpose I/O Installation

General purpose I/O (such as modems, paper tape readers and punches, etc.) must be installed in slot 2. Only those cards noted in Table 1 will be recognized, although other types of cards may be used with interface software supplied by the manufacturer of the card. For more details on interfacing foreign hardware, see the Software Details section, and the CONFIGIO program in the Software Utilities Manual.

## Using an External Terminal Interface

Any of the type 2, 3, or 4 cards of Table 1 can be used to interface an external terminal to Apple CP/M. The terminal interface card must be installed in slot 3.

The SoftCard supports both the Videx Videoterm and M&R Sup-R-Term 24 × 80 character video cards. Other plug-in video boards may be used with interface software supplied by the board manufacturer.

If an interface card is plugged into slot 3, the I/O interface card is used as the terminal device, rather than the Apple 24 × 40 screen and keyboard. If you do have an external terminal interface, we suggest that you remove it from slot 3 and use the normal Apple screen and keyboard until you have configured Apple CP/M for use with your terminal. See CONFIGIO in the Software Utilities Manual.

If you are using an *external* terminal, we suggest that you use either a California Computer Systems 7710A Serial interface or a modified Apple Communications Interface to interface the terminal to your Apple CP/M system. The Apple High Speed Serial Interface will be tolerated, but is not recommended because there is no way for CP/M to check the "status" of this device (i.e., you won't be able to "Ctrl-C" out of a BASIC program).

## Installation of the SoftCard

Now you are ready to install the SoftCard. First,

### **MAKE SURE THAT YOUR APPLE IS TURNED OFF!!**

Serious damage to your Apple and to the SoftCard will result if your Apple is left on during installation.

1. With the card laying component-side up in front of you, notice the four small switches on the Apple SoftCard. Make sure that all of these

switches are OFF. The side of the switch nearest the gold-plated edge connector is DOWN when in the off position. This is the standard operating position for Apple CP/M.

2. With your Apple computer positioned with the keyboard directly in front of you, clear the top of the Apple of miscellaneous monitors, disks, old coffee cups and any other junk. Now remove the top by grasping the cover under its rear lip at each corner with one hand at each corner, pulling up gently till the cover pops loose from its fasteners. Then pull the cover directly out toward the rear of the machine and remove it from your Apple. (The power is off isn't it?)
3. Now you must decide into which slot to install the SoftCard. You may plug the card into any unused slot (except slot zero), but we suggest you install it in slot 4. If slot 4 is occupied by a disk controller card, simply choose any other unused slot.
4. Position the SoftCard's connectors directly over the chosen expansion slot on the Apple's circuit board. Holding the board firmly and vertically, push the connector down into the expansion slot. Insure that the SoftCard is inserted all the way by rocking it gently fore and aft while applying downward pressure. Insure that the SoftCard is not tilted down toward the front of the Apple as this could cause the rear connector fingers to not be fully seated in the expansion slot (which would lead to results that are best not thought about).
5. Make sure that all of your peripheral cards are installed correctly as per the instructions on page 1-2.
6. Carefully replace the Apple's cover. Be sure that the corners pop into place and secure the lid. Now you can rearrange all of your junk just as before.

Now your SoftCard system is ready for use. Checkout of the system consists of bringing up CP/M and using it. BUT, before you turn on your Apple, please read the sections on "Bringing Up Apple CP/M" and "How To Copy Your SoftCard Disk." It is possible to destroy your disks if you do not follow the information in the two sections. So, **KEEP READING AND DON'T TURN ON ANYTHING YET.**

## **Chapter 2**

### **Getting Started with Apple CP/M**

- **Bringing Up Apple CP/M**
- **How to copy your SoftCard Disk**
- **Creating CP/M System Disks**
- **Using Apple CP/M with the Language Card.**
- **I/O Configuration**

In the pages to follow, we will show you how to bring up Apple CP/M. PLEASE read this section CAREFULLY and COMPLETELY before you power up your Apple!! You should read completely and understand all the information on pages 1-2 to 1-7 before proceeding.

## Bringing up Apple CP/M

Starting Apple CP/M is simple, but first you must be sure you are using the correct disk.

Two disks are included in the SoftCard package — one in 16-Sector format and the other in 13-Sector format. If you are currently using Apple DOS version 3.3 or Apple Pascal with the Language Card, you must use the 16-Sector disk. If you are currently using DOS 3.2 or earlier, you must use the 13-Sector disk. A 16-Sector disk will NOT boot on a drive set up for 13-Sector disks, and vice-versa.

Select the disk appropriate for your system and insert it into drive A:. (You'll have to start getting used to these drive names — A: is slot 6, drive 1.)

*If you have an Apple II Plus or an Apple II with an Autostart ROM installed, simply turn the Apple's power on, which will automatically boot the disk.*

*If you have a standard Apple II without an Autostart ROM, boot the disk by first turning the Apple's power on, hitting the RESET key, and then typing 6 Ctrl-K RETURN. Ctrl-K is typed by first pressing the key marked CTRL and holding it down while you press the K key.*

After a few seconds, the computer will display

```
APPLE II CP/M
44K vers. 2.2X
(C) 1980 MICROSOFT
```

```
A>
```

**NOTE:** If the sign-on message above is not displayed, check to be sure you are using the correct SoftCard disk. Also check to make sure that you have inserted all of your peripheral cards properly.

The "A>" prompt means that CP/M is ready for your command. To see that CP/M is really working, type

```
DIR
```

and press RETURN to display the names of all of the programs on your SoftCard Master disk. The DIR command and the rest of the CP/M commands will be explained in detail later.

But first, you should . . .

### **MAKE A BACKUP COPY OF YOUR SOFTCARD CP/M MASTER DISK!**

and save the original in a nice, safe, dry, non-magnetic place. In fact, it is a good idea to make more than one copy!

## **How To Copy Your SoftCard Disk**

**NOTE:** The process below works with both single- and multiple-drive systems. For more information on the use of the FORMAT and COPY programs, see the "Software Utilities Manual."

Copying a CP/M disk is a two-step process. The first step is to use the FORMAT program to "format" a blank disk to use as the backup disk. This process initializes the disk so that it can accept data. Next, you use the COPY program to COPY the master disk onto the newly formatted backup disk.

**NOTE:** CP/M, unlike Apple DOS, does not place the system software on each disk. This means that there are not "slave" or "master" disks in the same sense as with Apple DOS. We refer to the disks shipped with your SoftCard system as "Master Disks" only in the sense that you should save and protect these disks, and not in an operational sense. Also, CP/M disks will not boot up unless the system software is on that particular disk. You must first load CP/M from the system disk before you use any standard CP/M disk.

### **Formatting the backup disk**

Assuming CP/M is up and running (you should see the A> prompt), and you still have the SoftCard disk in drive A:, type:

**FORMAT A:**

and press RETURN. Soon, the Apple will respond by printing:

**APPLE II CP/M  
xx SECTOR DISK FORMATTER (xx 13 or 16 Sector depending  
(C) COPYRIGHT MICROSOFT 1980 on which disk you are using)**

**INSERT DISK TO BE FORMATTED INTO DRIVE A:**

Now remove the SoftCard system disk and insert your blank disk. When you are ready to begin, just hit RETURN. Make sure that you have the blank backup disk in the drive when you press RETURN.

The formatting process takes about 30 seconds. The disk drive will remain on during the entire process (you should be able to hear it operating).

When the FORMAT process is complete, the disk will stop and the Apple will type:

FORMAT COMPLETED  
INSERT SYSTEM DISK AND PRESS RETURN

When the red light on the disk drive goes out, remove the newly formatted disk and re-insert the SoftCard system disk. Then press RETURN to return to CP/M. After a second or two, the A> prompt will reappear, letting you know that you have returned to CP/M.

## **Copying the backup disk**

Now you are ready to copy your SoftCard system disk with the COPY program.

Type:

COPY A: = A:

After a few seconds, the Apple will display:

|                             |                             |
|-----------------------------|-----------------------------|
| APPLE II CP/M               | (xx is 13 or 16 Sector      |
| xx SECTOR DISK COPY PROGRAM | depending on which disk you |
| (C) MICROSOFT 1980          | are using)                  |

INSERT MASTER DISK    PRESS RETURN

Since you want to copy the disk that is already in drive A:, just press RETURN to begin the COPY process. The disk will whirr for a few seconds, then the computer will print:

INSERT SLAVE DISK    PRESS RETURN

Remove the SoftCard Master disk and insert your freshly formatted backup disk into drive A: and hit RETURN. Again after a few seconds, the computer will prompt:

INSERT MASTER DISK  
PRESS RETURN

Now remove the backup disk and re-insert the master disk, and hit RETURN.

Finally, the computer will ask you to re-insert the slave disk. This process will be repeated three times.

After you have inserted the slave disk into drive A: for the last time, the computer will display:

COPY COMPLETE  
DO YOU WISH TO MAKE ANOTHER COPY? (Y/N)  
PRESS RETURN

Since the disk in the drive is an exact copy of the SoftCard disk, you do not need to re-insert the SoftCard Master Disk. You should now store the SoftCard Master Disk away in a nice, safe, dry, non-magnetic place for safekeeping.

It is a good idea to make at least two backup copies of your SoftCard Master Disk. If you ever have problems that are not immediately identifiable as hardware or software, having a second backup will allow you to test your system without risking your SoftCard Master Disk.

If you have a Language Card, you should definitely make at least three copies as you will need to modify CP/M to take advantage of the additional Language Card memory. We strongly recommend that you do this modification on backup disks and not on your SoftCard Master Disk.

## **Creating CP/M System Disks**

A CP/M System disk is a disk that will load and initialize CP/M when booted. Creation of CP/M System disks is a two step process: first you must FORMAT the disk, then you must use the COPY program to write the CP/M system onto the disk that will load and run when the system is booted. Below is outlined the process for creating system disks:

1. Use the FORMAT program to format a blank disk. This process is exactly the same as the FORMAT process that you used to copy your SoftCard Master disks earlier.
2. Next, you must use the COPY program to write the CP/M system onto the disk. This is done using the "/S" option as shown below:

## Use of the COPY program

1. Insert a CP/M system disk that contains the COPY program into drive A: and boot your system. When you see the A> prompt, type

COPY A: = A:/S

The “/S” means that you only want to copy the CP/M system, not the entire disk. After a second, the computer will display

INSERT MASTER DISK      PRESS RETURN

Since your disk containing COPY also contains CP/M, just leave the current disk in drive A and press RETURN.

The disk will whirr for a few seconds then the computer will display the message:

INSERT SLAVE DISK      PRESS RETURN

Then, insert the disk you want to write the CP/M system onto, and hit RETURN. After a few seconds, the disk will stop and the computer will display

INSERT CP/M SYSTEM DISK INTO DRIVE A:  
PRESS RETURN

Since the disk in the drive is now a CP/M system disk, you can just hit RETURN to return to CP/M.

Your new CP/M system disk will now boot and can be used to store programs and data.

If you have more than one disk drive, or if you wish to create more than one system disk at a time, you should read the “Software Utilities Manual” for more complete information on the use of FORMAT and COPY.



# Using Apple CP/M with the Apple Language Card

If you are using the Apple Language Card, it is possible to take advantage of the extra 12K of addressable memory contained on the card. This extra 12K of memory makes 56K of contiguous memory space available for use with CP/M. First, however, you must update your CP/M system disk so that 56K CP/M, rather than 44K CP/M, will be invoked when the disk is booted. This is done with the CPM56 utility.

**NOTE:** Updating your CP/M disks in this way does not affect the operation of CP/M. However, a 56K CP/M disk will *NOT BOOT* on a system that is not equipped with a Language Card. We suggest that you do NOT update your SoftCard CP/M Master disk to 56K CP/M. Instead, use one of the backup copies you have just finished making.

To use the CPM56 utility, first make sure CP/M is up and running, (you should see the "A>" prompt) and insert your backup copy of the SoftCard system disk. Then, type:

CPM56 A:

and hit RETURN. Once you press RETURN, the computer will automatically update your disk. When the conversion is complete, the computer will display the message

DISK IN DRIVE A: HAS BEEN UPDATED TO 56K

You now have a diskette containing CP/M configured for a 56K system. To load this new version, RE-BOOT your system by either hitting RESET, 6, Ctrl-K (if you don't have an Autostart ROM), or by turning your Apple off and back on again. Soon, the prompt message will re-appear, this time displaying "56K CP/M" instead of "44K CP/M."

## I/O Configuration

I/O Configuration is the last step in setting CP/M up for your system. This step is not necessary on all systems but you will need to perform it *IF*:

1. You are using an external terminal
2. You wish to patch non-standard I/O software to the CP/M system

The CONFIGIO program is used to perform all of the system configuration process described below. Read the section on CONFIGIO in the "Software Utilities Manual" carefully for more information on the use of CONFIGIO.

Here are the final configurations that may be performed:

**Redefining Keyboard Characters** – If you wish to make it possible to type a character that is not normally available on the Apple keyboard (or on your external terminal if you use one), you can use the CONFIGIO utility of Apple CP/M to redefine the ASCII value that is assigned to any particular key on the keyboard. Since many CP/M programs use characters not found on the Apple keyboard, you will probably find it valuable to use this option. See both Chapter 2 of the "Software and Hardware Details Manual" and CONFIGIO in the "Software Utilities Manual" for complete information on redefining keyboard characters.

**Loading User I/O Driver Software** – The I/O Configuration Block also provides for the support of non-standard Apple peripherals and I/O software. To interface a non-standard peripheral (i.e., a peripheral that the SoftCard does not normally support, see list on page 1-2), you must load the interface software provided by the peripheral manufacturer into the I/O Block. There are specific restrictions regarding the software that can be loaded. For a complete description of these restrictions and for the actual loading process, see both Chapter 2 of the "Software and Hardware Details Manual" and "CONFIGIO" in the "Software Utilities Manual."

**Configuring Apple CP/M for use with an External Terminal** – If you are using an external terminal, you must configure Apple CP/M for use with your terminal. This configuration process is necessary because Apple CP/M supports a number of special screen and cursor control functions (e.g. Clear Screen and Address Cursor) that are used by a number of CP/M programs, such as Microsoft BASIC and the many CP/M word processors. These screen functions are invoked on most terminals by sending a sequence of characters to the terminal, which then performs the appropriate function. So, Apple CP/M must be made to recognize the particular screen function command sequences for your terminal.

Apple CP/M supports most popular video terminals, including the SOROC IQ 120/140, the Hazeltine 1500/1510, and the popular 24 × 80 plug-in video boards, such as the Videx Videoterm and the M&R Sup-R-Term.

As mentioned earlier in the section on installation of the SoftCard, the terminal interface card must be installed in slot 3 of your Apple. "See Apple Peripheral Cards: What Goes Where," page 1-2 for more information on the types of terminal interface cards supported by Apple CP/M.

Terminal configuration is done using a program written in Microsoft BASIC: CONFIGIO. The use of this program, and the procedure for configuring Apple CP/M to your system can be found in the "Software Utilities Manual."



## **Chapter 3**

### **An Introduction to Apple CP/M**

- **Typing at the Keyboard**
- **Output Control**
- **CP/M Warm Boot: Ctrl-C**
- **Changing CP/M Disks**
- **CP/M Command Structure**
- **CP/M File Naming Conventions**
- **File Name Specification**
- **Some CP/M Commands: DIR, ERA, REN, TYPE**
- **CP/M Error Messages**
- **Definitions of Programs Included on the SoftCard Disk**

The information presented in this section is intended to be used as a short introduction to CP/M on the Apple II. It will help you get started using CP/M but is in no way intended to replace the standard CP/M documentation as a guide to the complete usage of CP/M. Read the CP/M Reference Manual carefully.

The heart of the CP/M operating system does not lie in the power of its built-in keyboard commands. Instead, CP/M was designed as a link between a computer's hardware and its software. This is the reason for its wide popularity — a program written for CP/M on one machine can be easily transported to another.

Most CP/M “commands” (with the exception of a few such as DIR) are actually *programs* on a disk and so are extensible. To invoke commands of this type, the appropriate disk must be in your drive. Commands executed by loading their program code from the disk in this way are called “transient commands.” The COPY and FORMAT commands you used to back up your system disk are transient commands.

## Typing at the Keyboard

Typing at the keyboard with CP/M is quite a bit different than with Integer BASIC or Applesoft. The backspace key deletes the character under the cursor as it moves, and the forward arrow key doesn't work. None of the ESCape key cursor movement/editing features are supported.

However, CP/M supports a few line editing features that are useful when typing at the keyboard. There are also some other important control characters that can be used to perform other useful functions. (Remember: Control characters (denoted by “Ctrl-”) are typed by first hitting the CTRL key and holding it down while you type the indicated character).

|        |                                                                                                                                                           |
|--------|-----------------------------------------------------------------------------------------------------------------------------------------------------------|
| <--    | Backspaces one character position. The backspace key deletes the character under the cursor. (Also invoked with Ctrl-H)                                   |
| Ctrl-X | Backspaces up to the beginning of the line, deleting the line.                                                                                            |
| Ctrl-R | Retypes current line.                                                                                                                                     |
| Ctrl-J | Terminates input same as RETURN key. (Also invoked with LINE FEED)                                                                                        |
| Ctrl-E | Physical end of line. Cursor is moved to beginning of next line, but line is not terminated until RETURN is typed.                                        |
| RUBOUT | Deletes and “echos” (reprints) the last character typed. Also referred to as DEL or DELETE. (Type Ctrl-@ to get RUBOUT on the Apple keyboard — see below) |

memory at all times which is used to allocate space on the disk. When you change disks, this information must be replaced with the directory information of the newly inserted disk.

To let CP/M know that you have changed disks, type Ctrl-C to execute a CP/M "Warm Boot." Make sure you do this AFTER you have changed disks. This will cause the disk directory information in the drive to be updated. You should get used to typing Ctrl-C often.

If you do not type Ctrl-C before changing disks and a WRITE is attempted to the changed disk, the computer will display

BDOS ERR ON x:Disk R/O (Where x: is a disk drive A:-F:)

(R/O stands for Read Only) When you receive this error message, hit RETURN. This will perform a CP/M warm boot and return you to CP/M. The above error condition applies only to changed disks that are to be WRITTEN. No error will result if you attempt to READ from the changed disk.

Many CP/M programs perform a warm boot upon termination. So, you need not type Ctrl-C to change disks after execution of programs of this type. After a while you will probably recognize the sound of your Apple disk drive during a CP/M warm boot. This is one way to know whether a program performs a warm boot upon completion.

For more information, read the "CP/M Reference Manual — An Introduction to CP/M Features and Facilities." Also see "CP/M Error Messages" later in this section.

## The RESET Key

Pressing the RESET will have different effects, depending on whether your system has an Autostart ROM or not.

**On a system that has an Autostart ROM.** Pressing the RESET key while in CP/M will cause a CP/M warm boot, and you will return to CP/M. Pressing the RESET key while in either MBASIC or GBASIC will result in a "Reset Error," which can be trapped using ON ERROR GOTO, etc.

**On a system that does not have an Autostart ROM.** You can recover from hitting RESET by typing Ctrl-Y then pressing RETURN. You will then either re-boot CP/M (if you hit RESET while in CP/M) or return to BASIC with a "Reset Error" (if you hit RESET while in MBASIC or GBASIC).

There are a few characters that are normally unavailable on the Apple's keyboard. These have been assigned to certain control characters so that they are available to you:

| Type:  | To get:          |
|--------|------------------|
| Ctrl-K | [ (Left Bracket) |
| Ctrl-@ | RUBOUT           |
| Ctrl-B | \ (Backslash)    |

These characters are often required by CP/M commands and programs. To change (or do away with) these assignments, or add additional ones, see the CONFIGIO program in the "Software Utilities Manual."

## Output Control

There are two control characters that are used to control character output to the screen and printer:

|        |                                                                                                                                                              |
|--------|--------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Ctrl-S | Temporarily stops character output to the terminal. Program execution and character output resume when any character is typed.                               |
| Ctrl-P | Sends all character output to the line printer device as well as to the terminal. This "printer echo" mode remains in effect until the next Ctrl-P is typed. |

## CP/M Warm Boot: Ctrl-C

There is also another important control character: Ctrl-C. When typed as the first character of a line, Ctrl-C is used to perform a CP/M "Warm Boot," causing CP/M to be reloaded from the disk to insure that the CP/M in memory is in working order. (This is NOT the same as a *Cold* Boot. A Cold Boot is the act of booting the CP/M disk for the first time.) You should ALWAYS type Ctrl-C whenever you change disks. (See "Changing CP/M Disks," below.)

|        |                           |
|--------|---------------------------|
| Ctrl-C | Perform a CP/M warm boot. |
|--------|---------------------------|

## Changing CP/M Disks

Unlike Apple DOS, you cannot indiscriminately change disks in drives with CP/M. When you change disks, you must let CP/M know that you have done so. This is because there is certain disk directory information stored in



# CP/M Command Structure

When you see the "A>" prompt, you know that CP/M is ready for your command. The "A" in the prompt means that drive A: is the "currently logged drive." The "currently logged drive" is the default drive that is used in a file specification if another drive is not specified. It is also the drive that CP/M searches for transient commands if a drive is not specified in the command.

CP/M commands themselves are generally very simple. There are only a handful of non-transient commands, the most useful of which are DIR, ERA, and REN. The DIR command is used to display a disk directory, the ERA command is used to erase disk files, and the REN command is used to rename disk files.

## CP/M File Naming Conventions

Before you are introduced to these CP/M commands, you should become familiar with CP/M disk file naming conventions. CP/M file names are very different than those used with Apple DOS. A file name may be up to 8 characters long, with an optional 3 character "extension." This is a handy construct that lets you identify related files on the disk.

### File Name Specification

The CP/M file specification structure allows you to refer to one *or more* files with a single specification. Files are usually specified in a command by typing the name (up to 8 characters), followed by a period (".") and the 3 character extension. It is also possible to specify the drive in which the file is located. This is done by preceding the file name with the drive name. If no drive is specified, the currently logged drive is assumed. Below are some examples of valid CP/M file name specifications:

|             |                                                       |
|-------------|-------------------------------------------------------|
| A:FNAME.EXT | Refers to file FNAME.EXT on drive A:                  |
| TEMP.OLD    | Refers to file TEMP.OLD on the currently logged drive |
| B:TEMP.NEW  | Refers to file TEMP.NEW on drive B:                   |

The 3-character extension usually provides information about the internal format of a file. The most important of these common extensions is COM, which stands for COMMAND. Any file with an extension of COM is a transient command type file and can be invoked by simply typing its name (without the .COM). Other common extensions are BAS, used for BASIC programs; and HEX, ASM, and PRN, which are used (and produced) by the ASM program, which is the CP/M 8080 assembler.

File specifications can also be used to refer to more than one file at a time. This is done by the use of “wild card” file name specifications. A question mark used in a file name is a “wild card” character, that is, it will match any character in that position when searching the directory for the file name match. An asterisk (“\*”) is used to match any string of characters. For instance,

B:TEMP.???

or

B:TEMP.\*

refer to both TEMP.OLD and TEMP.NEW on drive B:, if they exist. Below are some more examples of “wild card” file specifications:

|                |                                                                               |
|----------------|-------------------------------------------------------------------------------|
| A:*.COM        | Refers to all files on drive A: with an extension of COM                      |
| B:*. *         | Refers to all files on drive B:                                               |
| B:????????.??? | Exactly the same as B:*. * above.                                             |
| DUMP.*         | Refers to all files on the currently logged disk beginning with “DUMP”        |
| C*.*           | Refers to any file on the currently logged disk beginning with the letter “C” |

Note that an “\*” is actually an abbreviation of a string of “?”s.

## Some CP/M Commands: DIR, ERA, REN, TYPE

These are the four most commonly used built-in CP/M commands. DIR is used to display the directory of all files on a disk; ERA is used to erase disk files; REN is used to rename disk files; and TYPE is used to display a text file on the terminal. Below is a short introduction to each.

**NOTE:** The information below is meant only as an introduction to a few of the CP/M commands. For more complete information about these and other CP/M commands, see the “CP/M Reference Manual — An Introduction to CP/M Features and Facilities.”

### The DIR Command

The DIR command is used to display the names of the files on a disk. To display the directory of all the files on the currently logged disk, type

DIR

and press RETURN. To display a directory of the disk in another drive, just include the drive name. For instance,

DIR B:

will display the directory of the disk in drive B:.

If a file specification is included with the DIR command, only those files whose names match the file specification will be displayed. Here are some examples of the DIR command used with file specifications:

|                |                                                                      |
|----------------|----------------------------------------------------------------------|
| DIR MBASIC.COM | Displays MBASIC.COM if the file exists on the currently logged disk. |
| DIR A:*.COM    | Displays all files with an extension of COM on drive A:              |
| DIR B:         | Displays all files on drive B:                                       |
| DIR A:A*.*     | Displays all files on drive A: whose name begins with the letter "A" |

If there are no files on the disk, or if no files match the file specification, CP/M will respond

NO FILE

## The ERA Command

The ERA command is used to erase files on the disk. You must always include a file specification with this command.

**NOTE:** *Don't* delete any of the files on your CP/M disk! If you do, you'll have to make another backup copy of the SoftCard Master disk.

Here are a few examples of the use of the ERA command:

|                |                                                                                                                                                                                                                 |
|----------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| ERA B:TEMP.OLD | Erase the file TEMP.OLD on drive B:                                                                                                                                                                             |
| ERA C:*.BAK    | Erase all files on drive C: with extension BAK                                                                                                                                                                  |
| ERA *.*        | Erase all of the files on the currently logged disk. If you attempt to erase all of the files on a disk, CP/M will ask ALL (Y/N)?. If you don't want to delete all the files on the disk, respond by typing "N" |

Notice that you can erase more than one file at a time with ERA by using the wild card naming convention.

## The REN Command

The REN command is used to rename files. Here is the general format of this command:

REN newname = oldname

where "newname" and oldname" are file specifications. You *cannot* use wild card file specifications with the REN command. You *can* precede the first file specification with a drive name. Below are some examples of the use of the REN command:

REN TEMP.NEW = TEMP.OLD

Rename TEMP.OLD as  
TEMP.NEW

REN B:PEAR.COM = APPLE.COM

Rename APPLE.COM on  
drive B: as PEAR.COM

**NOTE:** Unlike Apple DOS, the new file name *precedes* the existing file name (as in algebra, what's on the left side of the "=" becomes what's on the right).

## The TYPE Command

The TYPE command is used to display the contents of a text file on the terminal. You must include a file specification. (Wild card file specifications are not allowed.)

For example, to display the contents of the file DUMP.ASM on the screen, type

TYPE DUMP.ASM

and press RETURN. If you attempt to TYPE a file that is not a text file, only junk will appear.

**NOTE:** DUMP.ASM is the only text file on the SoftCard Master disk.

## CP/M Error Messages

There are four possible CP/M error messages. Below is listed each message, followed by a list of the possible causes, in the order of their likelihood:

## **BDOS ERR ON x:BAD SECTOR**

(Where x: is a disk drive A:-F:)

This error message can mean any number of things — it does NOT necessarily mean that there is a bad sector on your disk (but it could!). This error message is roughly equivalent to the Apple DOS “DISK I/O ERROR” message. Possible causes:

1. No disk in drive
2. Drive door not closed
3. Disk inserted improperly
4. An attempt was made to access a drive not installed in a controller card (See SELECT error below)
5. A bad disk

When you receive a BAD SECTOR error, CP/M waits for you to type a character from the keyboard. If you type Ctrl-C, a Warm Boot will be performed and you will return to CP/M command mode. Type R to retry the read or write and continue execution. Any other character will cause the error to be ignored and resume execution of the program or operation.

## **BDOS ERR ON x:R/O**

(where x: is a disk drive A:-F:)

This error message usually means one of two things:

1. You have changed the disk in a drive without typing Ctrl-C
2. There is a write-protect tab covering the notch in the side of your disk

When you receive this error message, CP/M will wait for you to type a character at the keyboard. After you do so, a warm boot will be performed and you will be returned to CP/M.

## **BDOS ERR ON x:FILE R/O**

(where x: is a disk drive A:-F:)

This error message can mean only one thing:

1. A write was attempted to a file that was marked Read Only with the STAT program

When you receive this error message, CP/M will wait for you to type a character at the keyboard. Type any key to perform a warm boot and return to CP/M.

For more information on write protection of files with STAT, consult the "CP/M Reference Manual — An Introduction to CP/M Features and Facilities."

## **BDOS ERR ON x:SELECT**

(where x: is a disk drive A:-F:)

This error message can mean only one thing:

1. An attempt was made to access a non-existent disk drive

When you receive this error message, CP/M will wait for you to enter a character from the keyboard. Type any character to perform a CP/M warm boot and return to CP/M.

**NOTE:** If you only have one drive attached to a disk controller card in your Apple (as is the case with a single-drive system), attempting to access the drive that is not installed will result in a BAD SECTOR error instead of a SELECT error.

## **Description of Programs Included on the SoftCard Disk**

MBASIC, GBASIC and a number of utility programs are found on the SoftCard disk. All of these programs are described in detail in other sections of the SoftCard Documentation package. Below is a synopsis of the purpose of each program, followed by a reference stating where the complete program documentation can be found.

### **APDOS**

This utility program allows you to transfer data from your Apple DOS disks to CP/M disks. APDOS may be used to transfer text and binary files only. (Requires 2 or more disk drives.)

See the "Software Utilities Manual"

### **ASM**

ASM is the CP/M 8080 assembler. ASM can be used along with DDT to write and debug 8080 assembly language programs.

See the "CP/M Reference Manual," Chapter 4.

## **CONFIGIO**

The CONFIGIO utility is used to configure the Apple CP/M operating environment to your particular system configuration. It has four major functions – to configure I/O for an external terminal, to redefine keyboard characters, to load user I/O software, and to read and write to the I/O Configuration Block. For more information about the function of I/O Configuration, see Chapter 2 of the “Software and Hardware Details Manual” in addition to the “Software Utilities Manual.”

See “Software Utilities Manual.”

## **COPY**

The COPY program is used to copy CP/M disks, or to create blank CP/M system disks from a newly formatted disk.

See the “Software Utilities Manual.”

## **DDT**

DDT is the CP/M Dynamic Debugging Tool. It allows dynamic interactive testing and debugging of 8080 assembly language programs.

See the “CP/M Reference Manual,” Chapter 5.

## **DOWNLOAD**

The DOWNLOAD and UPLOAD utilities enable the user to transfer CP/M files from another CP/M machine to the Apple by means of an RS-232 serial data link. UPLOAD is not included on either of the Apple CP/M disks. Use of these programs requires a working knowledge of 8080 assembly language programming and thus are intended for experienced programmers only.

See the “Software Utilities Manual.”

## **DUMP**

DUMP displays the contents of a disk file in hexadecimal form. DUMP.ASM is the source listing of the DUMP program, given in Chapter 2 of the CP/M Interface Guide, as an example of an 8080 assembly language program written for the CP/M environment.

See the “CP/M Reference Manual,” Chapter 1 and Chapter 2.

**ED** ED is the CP/M text editor. It is used to create and edit CP/M text files.

See the "CP/M Reference Manual," Chapter 3.

**FORMAT** FORMAT formats a blank disk so that it can accept data. A freshly formatted disk will not boot, but it can be used to store programs and data. Use COPY to make a newly formatted disk into a CP/M system disk.

See the "Software Utilities Manual."

**LOAD** LOAD is used to convert a disk file of extension .HEX into a machine-executable .COM file. LOAD can be used to convert output from the assembler into machine executable code.

See "CP/M Reference Manual," Chapter 1, "Introduction to CP/M Features and Facilities."

**MBASIC** This is Microsoft BASIC. This version of BASIC is disk BASIC that supports low-resolution graphics, sound, and game controls in addition to many features not found in Applesoft. This version does not support high-resolution graphics.

See the "Microsoft BASIC Reference Manual" for more information.

**PIP** PIP is one of the most frequently used CP/M programs. It is used to transfer files from one disk to another. It is also used to copy and append disk files. PIP may also be used to transfer files to the terminal devices and to the printer.

See the "CP/M Reference Manual," Chapter 1. For copying an entire disk, or for copying the CP/M system itself to another disk, see COPY in the "Software Utilities Manual."



**STAT**

STAT provides general status information about disk capacity, file sizes, file indicators and device assignments. File indicators and device assignments can also be altered using this program.

See the "CP/M Reference Manual," Chapter 1.

**SUBMIT**

SUBMIT allows CP/M commands and program input lines to be executed from a disk file rather than from the keyboard for automatic processing.

See the "CP/M Reference Manual," Chapter 1.

**XSUB**

XSUB, when used with SUBMIT, allows character input from a disk file *at all times during* execution of programs.

See the "CP/M Reference Manual," Chapter 1.

The following three programs are found only on the 16-Sector SoftCard disk:

**CPM56**

CPM56 is used to update a 44K CP/M system disk to a 56K system disk for use with the Apple Language Card. CPM56 cannot be used with 48K Apple systems.

See the "Software Utilities Manual"

**GBASIC**

GBASIC is the same as MBASIC except that it also supports high-resolution graphics.

See the "BASIC Reference Manual" for more information.

**RW13**

RW13 is used to allow 16-Sector CP/M to access files on a 13-Sector CP/M disk. Used with PIP, RW13 is especially useful for transferring files from a 13-Sector to a 16-Sector diskette. (Requires 2 or more disk drives.)

See the "Software Utilities Manual"



## **Chapter 4**

# **Getting Started with Microsoft BASIC**

Once you have made backup copies of your SoftCard disk, you'll be ready to begin exploring Microsoft BASIC. As mentioned previously, two versions of BASIC are included in the SoftCard package.

**MBASIC** Includes all of Microsoft BASIC, Version 5.0, plus low-resolution graphics and some other Applesoft extensions. (A comparison of MBASIC with Applesoft is included in the "BASIC Reference Manual.") MBASIC is found on both the 13-Sector and 16-Sector disks. The name of the file is MBASIC.COM.

**GBASIC** Includes all of the features of MBASIC *plus* high-resolution graphics. GBASIC is found only on the 16-Sector disk and its filename is GBASIC.COM.

To bring up either MBASIC or GBASIC, you must first be at CP/M command level as indicated on the screen by the A> prompt. If you don't see the prompt, return to page 1-8 Loading CP/M.

The initialization instructions below refer to MBASIC, but may also be used for loading GBASIC simply by substituting GBASIC where MBASIC is typed. Use of the two BASICs is identical except that in GBASIC you also have high-resolution graphics commands available to you.

Once you see the A> prompt, simply type:

**MBASIC**

then press RETURN. The computer will reply:

```
BASIC-80 Version 5.xx
Apple CP/M Version
Copyright ©1980 by Microsoft
Created: dd-mm-yy
xxxx Bytes Free
Ok
```

and BASIC is ready to accept commands.

Initialized in this way, BASIC sets certain default parameters: 3 files may be open at any one time during execution of a BASIC program; all the memory up to the start of FDOS in CP/M may be used and the maximum record size is set at 128.

If you wish to set these parameters (which are explained further in the "Microsoft BASIC Reference Manual") yourself, you can set certain "switches" when you type in the initialization command. You can also specify a program in the command line to be automatically run when the command is entered. This extended command line format is:

**MBASIC** [**<filename>**] [**/F:<number of files>**] [**/M:<highest memory location>**] [**/S:<maximum record>**]

(The square brackets ([ ]) indicate items that are optional and the angle brackets (< >) indicate items to be specified by you.)

**The <filename> option** allows you to RUN a program automatically after initialization is complete. A default extension of .BAS is used if none is supplied and the filename is less than nine characters long.

**The /F:<number of files> option** sets the number of disk data files that may be open at any one time during the execution of a BASIC program. Each file data block allocated in this fashion requires 166 bytes plus 128 (or number specified by /S:) bytes of memory. The <number of files> may be either decimal, octal (preceded by &O) or hexadecimal (preceded by &H).

**The /M:<highest memory location> option** sets the highest memory location that will be used by MBASIC. In some cases, it is desirable to set the amount of memory well below the CP/M's FDOS to reserve space for assembly language subroutines. In all cases, the highest memory location should be below the start of FDOS (whose address is contained in locations 6 and 7). The <highest memory location> may be decimal, octal (preceded by &O) or hexadecimal (preceded by &H).

**The /S:<maximum record size> option** sets the maximum size to be allowed by random files. Any integer may be specified, including integers larger than 128.

Here are a few examples of the different initialization options:

A>MBASIC PAYROLL.BAS

Use all memory and 3 files;  
load and execute  
PAYROLL.BAS

A>MBASIC INVENT/F:6

Use all memory and 6 files;  
load and execute  
INVENT.BAS

A>MBASIC/M;32768

Use first 32K of memory and 3 files

A>MBASIC DATAK/F:2/M:&H9000

Use first 36K of memory, 2 files and execute DATAK.BAS

When BASIC is initialized, it types the prompt "Ok." "Ok" means BASIC is at command level, that is, it is ready to accept commands. At this point, it may be used in either direct or indirect mode.

You can now write programs in either MBASIC or GBASIC, depending on which you initialized. Programming in Microsoft BASIC is like programming in Applesoft, but with significantly more power. See the "Microsoft BASIC Reference Manual" for complete documentation on programming in Microsoft BASIC.

This completes the Installation and Operations portion of this manual. At this point, you should have the SoftCard installed and have both CP/M and BASIC up and running. Throughout this section, we have referred you to other sections of the manual for more detailed information. These other sections *are very detailed* and should contain all the information that you need. If after searching carefully, you still cannot find some information, contact your dealer or write a letter to Microsoft Consumer Products. Enjoy yourself! We sincerely hope you will find the SoftCard an exciting and useful addition to your Apple.

# Software and Hardware Details





# **PART 2 SOFTWARE AND HARDWARE DETAILS**

## **Chapter 1 Apple II CP/M Software Details**

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## **Chapter 2 Apple II CP/M I/O Configuration Block**

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## **Chapter 3**

### **Hardware Description**

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# **CHAPTER 1**

## **APPLE II CP/M SOFTWARE DETAILS**

- **Introduction**
- **I/O Hardware Conventions**
- **6502/Z-80 Address Translation**
- **Apple II CP/M Memory Usage**
- **Assembly Language Programming with the SoftCard**
- **ASCII Character Codes**
- **Interrupt Handling**

# Introduction

This chapter deals with the software features that are peculiar to Apple II CP/M, and how these features relate to the I/O hardware installed in the different slots of the Apple. First we will discuss the hardware I/O protocol supported by Apple CP/M. Then we will examine the software support of this hardware protocol: the I/O Configuration Block. For more information on the use of the CP/M operating system, see the "CP/M Reference Manual."

## I/O Hardware Conventions

The I/O hardware protocol is identical to that supported by the initial release of Apple PASCAL, with a few exceptions. All standard Apple I/O peripherals are supported, as well as a few others, such as California Computer Systems' 7710A Asynchronous Serial Interface, the Videx Videoterm, and M&R Enterprises Sup-R-Term. Apple CP/M does not support horizontal scrolling on the Apple 24×40 video screen.

### Apple Peripheral Cards: What Goes Where

Unlike Applesoft and Integer BASIC (but similar to Apple PASCAL), Apple CP/M requires that peripheral I/O cards be plugged into specific slots depending on their functions. For instance, a printer interface card must be plugged into slot one in order to use a printer. When the system is booted, CP/M is able to recognize the presence or absence of certain standard Apple peripheral interface cards. Once the system is booted, I/O is performed by using either the hardware directly or by calling the 6502 software on the card.

Below is a table of the assigned functions for each of the Apple slots, along with the card types that are recognized when plugged into each. (See the list of recognized card types following the table.) Note that unless otherwise noted below, unrecognized cards or empty slots are ignored.

| SLOT | VALID CARD TYPES                | PURPOSE                                                                                                            |
|------|---------------------------------|--------------------------------------------------------------------------------------------------------------------|
| 0    | Not used for I/O                | This slot may contain a Language Card or an Applesoft or Integer BASIC ROM card. (the latter are not used by CP/M) |
| 1    | types 2,3,4                     | Line printer interface (CP/M LST: device)                                                                          |
| 2    | input: 2,3,4<br>output: 1,2,3,4 | General purpose I/O (CP/M PUN: and RDR: devices)                                                                   |

|   |             |                                                                                                                           |
|---|-------------|---------------------------------------------------------------------------------------------------------------------------|
| 3 | types 2,3,4 | Console output device (CRT: or TTY:)<br>The normal Apple 24 × 40 screen is used as the TTY: device if no card is present. |
| 4 | type 1      | Disk controller for drives E: and F:                                                                                      |
| 5 | type 1      | Disk controller for drives C: and D:                                                                                      |
| 6 | type 1      | Disk controller for drives A: and B:<br>(must be present)                                                                 |
| 7 | any type    | No assigned purpose. The SoftCard may be installed in slot 7.                                                             |

**NOTE:** The SoftCard may be installed in any empty slot except slot zero.

Below is a list of the I/O peripheral card types that are currently recognized by Apple CP/M.

#### **TYPE    CARD NAME**

|   |                                                        |
|---|--------------------------------------------------------|
| 1 | Apple Disk II Controller                               |
| 2 | Apple Communications Interface                         |
|   | *California Computer Systems 7710A Serial Interface    |
| 3 | Apple High Speed Serial Interface                      |
|   | Videx Videoterm 24 × 80 Video Terminal Card            |
|   | M&R Enterprises Sup-R-Term 24 × 80 Video Terminal Card |
| 4 | Apple Parallel Printer Card                            |

\*The CCS 7710A serial interface card is the preferred type 2 card as it supports hardware handshaking and variable baud rates from 110-19200 baud.

## **6502/Z-80 Address Translation**

Because of the memory address translation performed by the hardware on the SoftCard, a particular data byte is not accessed at the same address for both processors. The correspondence of memory addresses between the Z-80 and 6502 is shown below (All addresses are hexadecimal). Use of this table is necessary when translating 6502 BASIC or assembly language software for use with the SoftCard.

| <b>Z-80<br/>ADDRESS</b> | <b>6502<br/>ADDRESS</b> |                                        |
|-------------------------|-------------------------|----------------------------------------|
| 0000H-0FFFFH            | \$1000-\$1FFF           | Z-80 location zero                     |
| 1000H-1FFFFH            | \$2000-\$2FFF           |                                        |
| 2000H-2FFFFH            | \$3000-\$3FFF           |                                        |
| 3000H-3FFFFH            | \$4000-\$4FFF           |                                        |
| 4000H-4FFFFH            | \$5000-\$5FFF           |                                        |
| 5000H-5FFFFH            | \$6000-\$6FFF           |                                        |
| 6000H-6FFFFH            | \$7000-\$7FFF           |                                        |
| 7000H-7FFFFH            | \$8000-\$8FFF           |                                        |
| 8000H-8FFFFH            | \$9000-\$9FFF           |                                        |
| 9000H-9FFFFH            | \$A000-\$AFFF           |                                        |
| 0A000H-0AFFFFH          | \$B000-\$BFFF           |                                        |
| 0B000H-0BFFFFH          | \$D000-\$DFFF           |                                        |
| 0C000H-0CFFFFH          | \$E000-\$EFFF           |                                        |
| 0D000H-0DFFFFH          | \$F000-\$FFFF           | 6502 RESET, NMI, BREAK<br>vectors      |
| 0E000H-0EFFFFH          | \$C000-\$CFFF           | 6502 memory mapped I/O                 |
| 0F000H-0FFFFFH          | \$0000-0FFF             | 6502 zero page, stack, Apple<br>screen |

## Apple II CP/M Memory Usage

Here is how the Apple memory is used by Apple CP/M:

| <b>6502<br/>ADDRESS</b> | <b>Z-80<br/>ADDRESS</b> | <b>PURPOSE</b>                                           |
|-------------------------|-------------------------|----------------------------------------------------------|
| \$800-\$FFF             | 0F800-0FFFFH            | Apple disk drivers and disk buffers                      |
| \$400-\$7FF             | 0F400-0F7FF             | Apple screen memory                                      |
| \$200-\$3FF             | 0F200H-0F3FFF           | I/O Configuration Block.                                 |
| \$000-\$1FF             | 0F000H-0F1FFF           | Reserved 6502 memory area — 6502<br>stack and zero page. |
| \$C000-\$CFFF           | 0E000H-0EFFFFH          | Apple memory mapped I/O                                  |
| \$FFFA-\$FFFF           | 0DFAH-0DFFFFH           | 6502 RESET, NMI, and BREAK<br>vectors.                   |
| \$D400-\$FFF9           | 0C400H-0DFF9H           | 56K Language Card CP/M (if<br>Language Card installed)   |
| \$D000-\$D3FF           | 0C000H-0C3FFF           | Top 1K of free RAM space with<br>56K Language Card CP/M  |
| \$A400-\$BFFF           | 9400H-0AFFFFH           | 44K CP/M. (Free memory with<br>56K CP/M)                 |
| \$1000-\$A3FF           | 0000H-093FFF            | Free RAM (CP/M uses lowest 256<br>bytes)                 |

# Assembly Language Programming with the SoftCard

The Z-80 processor executes all of the 8080 instruction set plus its own set of instructions. You can run software written for either the 8080 or Z-80 processor on the SoftCard. There is, however, a different set of instruction mnemonics for each of the processors.

Included with the standard CP/M utilities are ED, a line oriented text editor; ASM, an 8080 assembler; and DDT, an 8080 machine language debugger. These programs can be used to write and debug 8080 programs.

It is also possible to write 6502 subroutines for use with the SoftCard. The Microsoft Assembly Language Development System is available separately for the development of both Z-80 and 6502 software.

## ASCII Character Codes

DEC = ASCII decimal code

HEX = ASCII hexadecimal code

CHAR = ASCII character name

| DEC | HEX | CHAR | WHAT TO TYPE     |
|-----|-----|------|------------------|
| 0   | 00  | NULL | ctrl @           |
| 1   | 01  | SOH  | ctrl A           |
| 2   | 02  | STX  | ctrl B           |
| 3   | 03  | ETX  | ctrl C           |
| 4   | 04  | ET   | ctrl D           |
| 5   | 05  | ENQ  | ctrl E           |
| 6   | 06  | ACK  | ctrl F           |
| 7   | 07  | BEL  | ctrl G           |
| 8   | 08  | BS   | ctrl H or ←      |
| 9   | 09  | HT   | ctrl I           |
| 10  | 0A  | LF   | ctrl J           |
| 11  | 0B  | VT   | ctrl K           |
| 12  | 0C  | FF   | ctrl L           |
| 13  | 0D  | CR   | ctrl M or RETURN |
| 14  | 0E  | SO   | ctrl N           |
| 15  | 0F  | SI   | ctrl O           |
| 16  | 10  | DLE  | ctrl P           |
| 17  | 11  | DC1  | ctrl Q           |
| 18  | 12  | DC2  | ctrl R           |

|    |    |        |                    |
|----|----|--------|--------------------|
| 19 | 13 | DC3    | ctrl S             |
| 20 | 14 | DC4    | ctrl T             |
| 21 | 15 | NAK    | ctrl U <i>or</i> → |
| 22 | 16 | SYN    | ctrl V             |
| 23 | 17 | ETB    | ctrl W             |
| 24 | 18 | CAN    | ctrl X             |
| 25 | 19 | EM     | ctrl Y             |
| 26 | 1A | SUB    | ctrl Z             |
| 27 | 1B | ESCAPE | ESC                |
| 28 | 1C | FS     | ctrl [             |
| 29 | 1D | GS     | ctrl shift-M       |
| 30 | 1E | RS     | ctrl ^             |
| 31 | 1F | US     | ctrl _             |
| 32 | 20 | SPACE  | space              |
| 33 | 21 | !      | !                  |
| 34 | 22 | "      | "                  |
| 35 | 23 | #      | #                  |
| 36 | 24 | \$     | \$                 |
| 37 | 25 | %      | %                  |
| 38 | 26 | &      | &                  |
| 39 | 27 | '      | '                  |
| 40 | 28 | (      | (                  |
| 41 | 29 | )      | )                  |
| 42 | 2A | *      | *                  |
| 43 | 2B | +      | +                  |
| 44 | 2C | ,      | ,                  |
| 45 | 2D | -      | -                  |
| 46 | 2E | .      | .                  |
| 47 | 2F | /      | /                  |
| 48 | 30 | 0      | 0                  |
| 49 | 31 | 1      | 1                  |
| 50 | 32 | 2      | 2                  |
| 51 | 33 | 3      | 3                  |
| 52 | 34 | 4      | 4                  |
| 53 | 35 | 5      | 5                  |
| 54 | 36 | 6      | 6                  |
| 55 | 37 | 7      | 7                  |
| 56 | 38 | 8      | 8                  |
| 57 | 39 | 9      | 9                  |
| 58 | 3A | :      | :                  |
| 59 | 3B | ;      | ;                  |
| 60 | 3C | <      | <                  |
| 61 | 3D | =      | =                  |
| 62 | 3E | >      | >                  |
| 63 | 3F | ?      | ?                  |
| 64 | 40 | @      | @                  |
| 65 | 41 | A      | A                  |
| 66 | 42 | B      | B                  |
| 67 | 43 | C      | C                  |



|     |    |   |            |
|-----|----|---|------------|
| 68  | 44 | D | D          |
| 69  | 45 | E | E          |
| 70  | 46 | F | F          |
| 71  | 47 | G | G          |
| 72  | 48 | H | H          |
| 73  | 49 | I | I          |
| 74  | 4A | J | J          |
| 75  | 4B | K | K          |
| 76  | 4C | L | L          |
| 77  | 4D | M | M          |
| 78  | 4E | N | N          |
| 79  | 4F | O | O          |
| 80  | 50 | P | P          |
| 81  | 51 | Q | Q          |
| 82  | 52 | R | R          |
| 83  | 53 | S | S          |
| 84  | 54 | T | T          |
| 85  | 55 | U | U          |
| 86  | 56 | V | V          |
| 87  | 57 | W | W          |
| 88  | 58 | X | X          |
| 89  | 59 | Y | Y          |
| 90  | 5A | Z | Z          |
| 91  | 5B | [ | [          |
| 92  | 5C | \ | \          |
| 93  | 5D | ] | ](shift-M) |
| 94  | 5E | ^ | ^          |
| 95  | 5F | — | —          |
| 96  | 60 | , | ,          |
| 97  | 61 | a | a          |
| 98  | 62 | b | b          |
| 99  | 63 | c | c          |
| 100 | 64 | d | d          |
| 101 | 65 | e | e          |
| 102 | 66 | f | f          |
| 103 | 67 | g | g          |
| 104 | 68 | h | h          |
| 105 | 69 | i | i          |
| 106 | 6A | j | j          |
| 107 | 6B | k | k          |
| 108 | 6C | l | l          |
| 109 | 6D | m | m          |
| 110 | 6E | n | n          |
| 111 | 6F | o | o          |
| 112 | 70 | p | p          |
| 113 | 71 | q | q          |
| 114 | 72 | r | r          |
| 115 | 73 | s | s          |
| 116 | 74 | t | t          |

|     |    |     |   |
|-----|----|-----|---|
| 117 | 75 | u   | u |
| 118 | 76 | v   | v |
| 119 | 77 | w   | w |
| 120 | 78 | x   | x |
| 121 | 79 | y   | y |
| 122 | 7A | z   | z |
| 123 | 7B | {   | { |
| 124 | 7C |     |   |
| 125 | 7D | }   | } |
| 126 | 7E | ~   | ~ |
| 127 | 7F | RUB |   |

## Interrupt Handling

Because of the way the 6502 is “put to sleep” by the SoftCard using the DMA line on the Apple bus, ALL interrupt processing must be handled by the 6502. An interrupt can occur at two times: while in Z-80 mode and while in 6502 mode.

### Handling an interrupt in 6502 mode:

Handle the interrupt in the usual way – simply end the interrupt processing routine with an RTI instruction.

### Handling an interrupt in Z-80 mode:

Both processors are interrupted when an interrupt occurs in Z-80 mode. Here is the step-by-step process for handling an interrupt while in Z-80 mode:

1. Save any registers that are destroyed on the stack.
2. Save the contents of the 6502 subroutine call address (See Calling of 6502 Subroutines above) in case an interrupt has occurred during a 6502 subroutine call.
3. Set up the 6502 subroutine call address to \$FF58, which is the address of a 6502 RTS instruction in the Apple Monitor ROM.
4. Return control to the 6502 by performing a write to the address of the SoftCard (again see Calling of 6502 Subroutines).
5. When control is returned to the Z-80, restore the previous 6502 subroutine call address.
6. Restore all used Z-80 registers from the stack.
7. Enable interrupts with an EI instruction.
8. Return with a RET instruction.

## **CHAPTER 2**

### **APPLE II CP/M**

### **I/O CONFIGURATION BLOCK**

- **Introduction**
- **Console Cursor Addressing/Screen Control**
  - The Hardware/Software Screen Function Table**
  - Terminal Independent Screen Functions/Cursor Addressing**
- **Redefinition of Keyboard Characters**
- **Support of Non-Standard Peripherals and I/O Software**
  - Assigning Logical to Physical I/O Devices: the IOBYTE**
  - Patching User Software Via the I/O Vector Table**
- **Calling of 6502 Subroutines**
- **Indication of Presence and Location of Peripheral Cards**

# Introduction

The I/O Configuration Block contains the information necessary to interface Apple CP/M to the various hardware and software configurations available to the Apple CP/M user. Every Apple CP/M system disk has its own I/O Configuration Block, which is loaded and initialized when the system is booted.

There are five primary functions of the I/O Configuration Block:

1. Console cursor addressing/screen function interface
2. Redefinition of keyboard characters
3. Support of non-standard peripheral devices and I/O software
4. Calling of 6502 subroutines
5. Indication of the presence and location of peripheral cards

Each is detailed in its own section in the following pages.

Note: The CONFIGIO program is used to examine and modify the I/O Configuration Block — See Part 5, “Software Utilities Manual” for more information.

## Console Cursor Addressing/Screen Control

Most popular video terminals, including the normal  $24 \times 40$  Apple screen, can support special features such as direct cursor addressing, screen clear, highlighted text, etc. Apple CP/M applications software such as word processors and business software can easily take advantage of these features.

These advanced screen functions are usually initiated by sending a certain sequence of characters to the terminal. The sequences required to perform a specific screen function are often different for different terminals. Most applications software designed to take advantage of these screen functions can be configured for a number of popular terminals. However, if your terminal is NOT compatible with your software, you must usually write some specialized machine language subroutines to take care of the problem. Since the Datamedia terminal screen function sequences supported by Apple PASCAL and the popular  $24 \times 80$  plug-in video boards are not considered “popular” by many CP/M applications programmers, they are rarely supported.

Under Apple CP/M, these problems are solved in most cases by translating the functions as they are received, into the corresponding function expected by the terminal hardware. This is achieved by two translation tables: the Software Screen Function Table and the Hardware Screen Function Table, both part of the I/O Configuration Block. Apple CP/M uses the Software Screen Function Table to recognize an incoming screen function sequence, which is then translated to the corresponding sequence found in the Hardware Screen Function Table. This sequence is then sent to the terminal device.

For example: Suppose that you want to use a CP/M screen-oriented word processor (designed to work with a SOROC IQ 120 terminal) with a Videx Videoterm 24×80 video board. The problem: Since the Videoterm board recognizes only the Datamedia type terminal character sequences, it does not recognize the screen function character sequences (meant for the SOROC) that the word processor sends.

To solve this problem, you would use the CONFIGIO utility (see the Software Utilities Manual) to encode the SOROC screen function sequences into the Software Screen Function Table and encode the Datamedia sequences into the Hardware Table. Now when your word processor sends characters to the terminal, they are compared to the SOROC function sequences that have been placed in the Software Screen Function Table. A match means that your word processor is attempting to perform a screen function. Next, the corresponding Datamedia character sequence is taken from the Hardware Screen Function Table and sent to the terminal, where the function is actually performed.

## **The Hardware/Software Screen Function Table**

There are nine screen functions supported by Apple CP/M:

1. Clear Screen
2. Clear to End of Page
3. Clear to End of Line
4. Set Normal (lowlight) Text Mode
5. Set Inverse (highlight) Text Mode
6. Home Cursor
7. Address Cursor
8. Move Cursor Up
9. Non-destructively Move Cursor Forward

The Backspace character (ASCII 8) is assumed to move the cursor backwards, and the Line Feed character (ASCII 10) is assumed to move the cursor down one line.

Screen function character sequences supported by Apple CP/M may be of two forms:

1. A single control character, or
2. Any ASCII character preceded by a single character lead-in.

Screen function sequences longer than two characters are not supported.

The internal format of each of the two 11-byte tables is identical. Below are listed the function number, the hexadecimal address and a description of each table entry.

| <b>FUNC. #</b> | <b>SOFTWARE</b> | <b>HARDWARE</b> | <b>DESCRIPTION</b>                                                                                                                                                                                                    |
|----------------|-----------------|-----------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|                | 0F396H          | 0F3A1H          | Cursor address coordinate offset. Range: 0-127. If the high order is 0, the X and Y coordinates are expected to be transmitted Y first, X last. If the high order bit is 1, the coordinates are sent X first, Y last. |
|                | 0F397H          | 0F3A2H          | Lead-in character. This byte is zero if there is no lead-in.                                                                                                                                                          |

**NOTE:** The following rules apply to the screen function table entries below: If the table entry is zero, the function is not implemented. If the entry has the high order bit set, the function requires a lead-in. An entry with the high order bit clear means the function does not require a lead-in.

|   |        |        |                                    |
|---|--------|--------|------------------------------------|
| 1 | 0F398H | 0F3A3H | Clear screen                       |
| 2 | 0F399H | 0F3A4H | Clear to End of Page               |
| 3 | 0F39AH | 0F3A5H | Clear to End of Line               |
| 4 | 0F39BH | 0F3A6H | Set Normal (low-light) Text Mode   |
| 5 | 0F39CH | 0F3A7H | Set Inverse (high-light) Text Mode |
| 6 | 0F39DH | 0F3A8H | Home Cursor                        |

|   |        |        |                                          |
|---|--------|--------|------------------------------------------|
| 7 | 0F39EH | 0F3A9H | Address Cursor (See above)               |
| 8 | 0F39FH | 0F3AAH | Move Cursor Up One Line                  |
| 9 | 0F39FH | 0F3AAH | Non-destructively Move<br>Cursor Forward |

The standard  $24 \times 40$  Apple screen supports all nine functions independent of the Hardware Screen Function Table. However, if a Software Screen Function Table entry is zero, that function will be disabled.

The Hardware and Software Screen Function Tables can be examined and modified with the CONFIGIO program. Use of this program and more information concerning terminal configuration can be found in the Apple CP/M Utilities Reference Manual.

## Terminal Independent Screen Functions/Cursor Addressing

Because of the general-purpose nature of the Hardware and Software Screen Function Tables, it is possible to write programs that use the information contained in these tables to perform screen functions. These programs would work with *any* terminal, as long as the Hardware Screen Function Table was set up correctly for the particular terminal. Below is a short segment of 8080 assembly language code that illustrates the use of the Screen Function Tables for terminal-independent screen programming:

```

;
;      Terminal Independent Screen I/O
;
;      This routine will execute the screen function
;      specified by E, where E contains the screen function
;      number from one to nine. If the function is not implemented,
;      the subroutine simply returns. All registers are destroyed.
;      (NK 5/80)
;
;      Equates:
;
BDOS      EQU    0005H      ;CP/M function call address
SXYOFF    EQU    0F396H    ;Software cursor address XY coord.
                                offset
SFLDIN    EQU    0F397H    ;Software function lead-in character
SSFTAB    EQU    0F398H    ;Software screen functions
;
SCRFUN:   MVI    D,0        ;Prepare for index
          LXI    H,SSFTAB-1 ;Point to Software Screen
                                Function table minus one
          DAD    D          ;Index to desired function char.

```





## **Redefinition of Keyboard Characters**

Some CP/M software requires specific keys for proper operation that are normally unavailable on some keyboards. The Apple keyboard is particularly deficient in this respect. Common characters such as the left square bracket ([), and RUBOUT simply cannot be typed. This problem is solved by the Keyboard Character Redefinition Table found in the I/O Configuration Block.

The function of the Keyboard Character Redefinition table is simple: it redefines any key on the keyboard as any of the ASCII character codes. For example, Ctrl-K could be redefined as the left square bracket. Then when Ctrl-K is typed, the [ character appears.

Another somewhat tricky use of Keyboard Character Redefinition is to disable BASIC program termination with Ctrl-C by redefining Ctrl-C as some other character such as NUL. Thus it would be impossible to break out of a BASIC program because it is impossible to type Ctrl-C. (It is also clear from this example that messing around with this table can cause some annoying problems.)

Keyboard redefinition takes place only during input from the TTY: and CRT: devices. (See Assigning Logical to Physical I/O devices below.)

### **The Keyboard Character Redefinition Table**

The Keyboard Character Redefinition Table will support up to six character redefinitions. The table is located at 0F3ACH from the Z-80. Entries in the table are two bytes: the first is the ASCII value of the keyboard character to be redefined, and the second is the desired ASCII value of the character. Both bytes must have their high order bits cleared.

If there are less than six entries in the Keyboard Character Redefinition Table, the end of the table is denoted by a byte with the high order bit set.

Modifications to the Keyboard Character Redefinition Table may be made using the CONFIGIO program. See the "Software Utilities Manual."

## **Support of Non-Standard Peripherals and I/O Software**

The I/O Information Block also provides for the support of non-standard Apple peripherals and I/O software. All of the primitive character I/O functions are vectored through the I/O Vector Table which is contained in the I/O Configuration Block. These vectors normally point to the standard I/O routine located in the CP/M BIOS, but they can be altered by the user to point to his own drivers. Three blocks of 128 bytes each are provided within

the I/O Configuration Block for user I/O driver software. Each of the three 128-byte blocks is allocated to a specific device, and thus to a specific slot, in order to prevent memory conflicts.

| <b>ADDR</b>   | <b>ASSIGNED<br/>SLOT</b> | <b>ASSIGNED<br/>LOGICAL DEVICE</b>  |
|---------------|--------------------------|-------------------------------------|
| 0F200H-0F27FH | Slot 1                   | LST: — line printer device          |
| 0F280H-0F300H | Slot 2                   | PUN: and RDR: — general purpose I/O |
| 0F300H-0F37FH | Slot 3                   | TTY: — the console device           |

Most Apple I/O interface cards have 6502 ROM drivers on the card. The easiest way to interface these types of cards to Apple CP/M is to write Z-80 code to call the 6502 subroutines on the ROM. This should be sufficient to interface most common I/O devices to Apple CP/M. (See Calling of 6502 Subroutines below.)

If no card is installed in a particular slot, its allocated 128-byte space can be used for other purposes relating to its assigned logical device. These include lower-case-input drivers for the Apple keyboard, cassette tape interface, etc.

I/O driver subroutines are patched to CP/M by patching the appropriate I/O vector to point to the subroutine. A table of vector locations and their purposes is shown below:

| <b>VEC<br/>#</b> | <b>ADDR</b> | <b>VECTOR NAME</b>       | <b>DESCRIPTION</b>                                                                       |
|------------------|-------------|--------------------------|------------------------------------------------------------------------------------------|
| 1                | 0F380H      | Console Status           | Returns 0FFH in register A if a character is ready to read, 00H in register A otherwise. |
| 2                | 0F382H      | Console Input vector #1  | Reads a character from the console into the A register with the high order bit clear.    |
| 3                | 0F384H      | Console Input vector #2  |                                                                                          |
| 4                | 0F386H      | Console Output vector #1 | Sends the ASCII character in register C to the console device.                           |
| 5                | 0F388H      | Console Output vector #2 |                                                                                          |

|    |        |                        |                                                                        |
|----|--------|------------------------|------------------------------------------------------------------------|
| 6  | 0F38AH | Reader Input vector #1 | Reads a character from the "paper tape reader" device into register A. |
| 7  | 0F38CH | Reader Input vector #2 |                                                                        |
| 8  | 0F38EH | Punch Output vector #1 | Sends the character in register C to the "paper tape punch" device.    |
| 9  | 0F390H | Punch Output vector #2 |                                                                        |
| 10 | 0F392H | List Output vector #1  | Sends the character in register C to the line printer device.          |
| 11 | 0F394H | List Output vector #2  |                                                                        |

**NOTE:** During Console Output, the B register contains a number corresponding to one of the nine supported screen functions during output of a screen function. B contains zero during normal character output. B is also non-zero during the output of the Cursor Address X Y coords after executing screen function #7.

## Assigning Logical to Physical I/O Devices: the IOBYTE

As explained in the CP/M reference documentation, the IOBYTE can be used to assign logical I/O devices to physical devices. The IOBYTE is changed with the STAT program. See the "CP/M Reference Manual" for more information on changing and using the IOBYTE.

The IOBYTE function creates a mapping of logical and physical devices which can be altered by CP/M programs or with the STAT utility. The mapping is performed by splitting the IOBYTE into four bit fields, as shown below:

|                  |             |              |               |                |
|------------------|-------------|--------------|---------------|----------------|
| IOBYTE at 0003H: | <b>LIST</b> | <b>PUNCH</b> | <b>READER</b> | <b>CONSOLE</b> |
| bits:            | 7 6         | 5 4          | 3 2           | 1 0            |

The value in each field can be in the range 0-3. The meaning of the values that can be assigned to each field is outlined below:

### CONSOLE field (bits 0,1)

- 0 - CONSOLE is the TTY: device
- 1 - CONSOLE is the CRT: device
- 2 - Batch mode — Uses the RDR: device as the CONSOLE input, and the LST: device as the CONSOLE output (BAT:)
- 3 - User defined CONSOLE device (UC1:)

### READER field (bits 2,3)

- 0 - READER is the TTY: device
- 1 - READER is the CRT: device
- 2 - READER is the "paper tape reader" device (PTR:)
- 3 - User defined READER device #2 (UR2:)

#### PUNCH field (bits 4,5)

- 0 - PUNCH is the TTY: device
- 1 - PUNCH is the "paper tape punch" device (PTP:)
- 2 - User defined PUNCH #1 (UP1:)
- 3 - User defined PUNCH #1 (UP2:)

#### LIST field (bits 6,7)

- 0 - LIST is the TTY: device
- 1 - LIST is the CRT: device
- 2 - LIST is the line printer device (LPT:)
- 3 - User defined LIST device (UL1:)

Below is a description of the Apple CP/M implementation of the physical devices mentioned above:

**TTY:** Either the standard Apple screen and keyboard or an external terminal installed in slot 3. This routine vectors through Console Input Vector #1 and Console Output #1. The Console status is always vectored through the Console Status vector.

**CRT:** Same as TTY:

**UC1:** User defined console device. This device is vectored through Console Input #2 and Console Output #2.

**PTR:** A standard Apple interface capable of doing *input* installed into slot 2. If no card is plugged into slot 2, the PTR: device always returns a 1AH end-of-file character. Input from the PTR: device is vectored through Reader Input vector #1. Characters are returned in the A register.

**UR1:** User defined reader #1. A character read from this device is returned in the A register. This input device is vectored through Reader Input vector #2.

**UR2:** User defined reader #2. This device is physically the same as UR2:.

**PTP:** Any standard Apple interface capable of doing *output* installed into slot 2. If no card is plugged into slot 2, the PTP: device does nothing. Output to the PTP: device is vectored through Punch Output vector #1.

**UP1:** User defined punch #1. The character in register C is output through Reader Input vector #2.

**UP2:** User defined punch #2. This device is physically the same as UP1:

**LPT:** The LPT: device is any standard Apple interface card installed into slot 1 capable of doing output. The character in register C is output through List Output vector #1.

**UL1:** User defined list device. The character in register C is output via List Output vector #2.

The IOBYTE can be changed with the STAT program, or it may be modified from an assembly language program using the CP/M Get IOBYTE and Set IOBYTE (#7 & #8) functions. See "An Introduction to CP/M Features and Facilities" and the "CP/M Interface Guide" in the "CP/M Reference Manual" for more information.

## **Patching User Software Via the I/O Vector Table**

User subroutines can be patched into the I/O Configuration Block with the CONFIGIO program. Any patches made can also be permanently saved onto a CP/M system disk as well as with CONFIGIO.

To create a code file, use ASM to write the driver software, and then use LOAD to create a COM file from the HEX file produced by ASM.

The code file loaded by CONFIGIO must be of a certain internal format. Only one code segment may be patched into the I/O Configuration Block per code file. However, as many vectors in the I/O Vector Table may be patched as desired.

Below is outlined the format of a disk code file to be loaded with CONFIGIO and patched to the I/O Configuration Block:

|               |                                                |
|---------------|------------------------------------------------|
| First byte:   | No. of patches to I/O Vector Table to be made. |
| Next 2 bytes: | Destination address of program code.           |
| Next 2 bytes: | Length of program code.                        |

Repeat for each I/O vector patch to be made:

|            |                                    |
|------------|------------------------------------|
| Next byte: | Vector Patch type — either 1 or 2. |
|------------|------------------------------------|

If Vector Patch type = 1 :

|            |                                                                                        |
|------------|----------------------------------------------------------------------------------------|
| Next byte: | Vector number to be patched. May be from 1-11. (See vector location definitions above) |
|------------|----------------------------------------------------------------------------------------|

|               |                                                                                                   |
|---------------|---------------------------------------------------------------------------------------------------|
| Next 2 bytes: | Address to be patched into the vector referred by the previous byte. Points into the user's code. |
|---------------|---------------------------------------------------------------------------------------------------|

If Vector Patch type = 2 :

|            |                                                                                           |
|------------|-------------------------------------------------------------------------------------------|
| Next byte: | Vector number to be patched. May range from 0-11. (See vector location definitions above) |
|------------|-------------------------------------------------------------------------------------------|

- Next 2 bytes: Address in which to place the current contents of the specified vector. (May be the address field of a JMP, etc.)
- Next 2 bytes: New address to be placed in the specified vector.
- Next: The actual program code is located after the patch information above. Convention restricts the size of the program code to 128 bytes per slot-dependent block. Use the block appropriate for your application and slot use. (See above)

Below is an example of a program that could be patched into the I/O Configuration Block using CONFIGIO. While it is listed here primarily as a model for writing your own programs, it is useful in its own right with a 24x80 video card or standard Apple video and keyboard, so you may want to enter it for your own use.

Notice how OFFSET is used to allow the program to be ORGed at 0100H.

To patch this program to the I/O Configuration Block, you would:

1. Use the DDT "S" command to enter the program into memory at 100 hex.
2. Use the CP/M SAVE command to save it to disk.
3. Use CONFIGIO option #3 to load the lower case driver into the I/O Configuration Block.
4. Use CONFIGIO option #4 to save the patched I/O Configuration Block to the disk.

If you patch this lower case input routine for your own use, note the following:

This driver defaults in upper case shift lock. The forward-arrow key is used as the shift key. Hit the arrow key once to enter lower-case input mode. Now, all characters typed will be entered in lower case. To shift a letter, hit the arrow key once—don't hold it down. The next character typed will be shifted. To enter shift-lock mode, hit the arrow key twice in a row.

```

;      APPLE CP/M LOWER CASE INPUT ROUTINE
;
; This routine can be assembled using ASH and
; LOAD to produce a file that can be loaded and
; patched into the I/O Configuration Block with
; CONFIGIO. It is also intended to be used as
; a model for your own programs.
;

```

```

0015 = SHFCHR EQU 21 ;Shift key is the forward-arrow
F3B9 = SLTYP EQU 0F3B9H ;Slot types table
E000 = KEYBD EQU 0E000H ;Address of Apple keyboard
;

0100 ORG 0100H ;This is so LOAD will load at 100h
F300 = ORIGIN EQU 0F300H ;Real origin of program
OFFSET SET ORIGIN-LWRCASE ;must be added to 16-bit addresses
;

0100 01 DB 1 ;Make one patch
0101 00F3 DW ORIGIN ;Destination address of program
0103 3E00 DW PRGEND-LWRCASE ;Length of program
;

0105 02 DB 2 ;Patch type 2
;

0106 02 DB 2 ;Patch Console Input vector #1
0107 06F3 DW OLDINP+OFFSET ;Place to put current contents of vector
0109 00F3 DW LWRCASE+OFFSET ;New contents of vector
;

; Check to make sure he isn't using an external terminal!
;

0108 3ABBF3 LWRCASE:LDA SLTYP+2 ;Is there a card in slot 3?
010E FE03 CPI 3 ;Is he using a Com Card as a terminal?
0110 CA0000 JZ 0000 ;Dummy address
0111 = OLDINP EQU $-2 ;Place to put normal input routine addr
;

; Get a character from the Apple keyboard:
;

0113 3A00E0 KBLOOP: LDA KEYBD ;See if char available at keyboard
0116 B7 ORA A ;Set condition codes on keybd loc
0117 F20BF3 JP KBLOOP+OFFSET ;Loop if char not available
011A 3210E0 STA KEYBD+10H ;Clear keyboard strobe
011B E67F ANI 7FH ;Mask high bit of char
011F 4F MOV C,A ;Save character in [C]
;

0120 0615 MVI B,SHFCHR ;Shift character into [B]
0122 2130F3 LXI H,STATE+OFFSET ;Point to shift state
0125 7E MOV A,M ;Get state.
0126 FE01 CPI 1 ;Determine state
0128 79 MOV A,C ;Get typed character into [A]
0129 DA36F3 JC STATE0+OFFSET ;Carry set - state 0
012C CA2EF3 JZ STATE1+OFFSET ;State 1
;

; Here if in lower case input mode.
; All alphabetic characters are converted
; to lower case, unless the shift character is
; typed, which enters 'shift next character' mode
;

012F B8 STATE2: CMP B ;for shift char.
0130 CA32F3 JZ SETONE+OFFSET ;It was, set state = 1
0133 FE40 CPI 64 ;It wasn't, so convert all
0135 D8 RC ;alphabetic chars to lower case
0136 EE20 XRI 00100000B ;This does the conversion
0138 C9 RET ;All done
;

; Here if in 'shift next character' mode, entered
; by typing the shift char once in lower case
; input mode. If shift character is typed again,
; upper case shift lock mode will be entered.
;

0139 34 STATE1: INR M ;Reset state = 2 = lower case mode
013A B8 CMP B ;Hit shift character?
013B C0 RNZ ;Let upper case character go.
013C 35 DCR M ;set state to zero; upper shift lock
013D 35 SETONE: DCR M
013E C300F3 JMP LWRCASE+OFFSET ;Get another character
;

; Here if in upper case shift lock mode.
; Shift character must be typed once to enter lower
; case input mode.
;

```

```

0141 B8      STATE: CMP      B      ;Did he type shift char?
0142 C0      RNZ              ;Not shift, return upper case char.
0143 3602     MVI      M,2      ;Set state = 2 = lower case input mode
0145 C300F3   JMP      LWRCASE+OFFSET ;and set another character
;
0148 00      STATE: DB      0      ;Shift state. Default = upper lock.
;
PRGEND:
0149                      END

0100 01 00 F3 3E 00 02 02 06 F3 00 F3 3A BB F3 FE 03
0110 CA 00 00 3A 00 E0 B7 F2 08 F3 32 10 E0 E6 7F 4F
0120 06 15 21 30 F3 7E FE 01 79 DA 36 F3 CA 2E F3 BB
0130 CA 32 F3 FE 40 D8 EE 20 C9 34 BB C0 35 35 C3 00
0140 F3 BB C0 36 02 C3 00 F3 00
-
-
-

```

## Calling of 6502 Subroutines

As discussed in the Hardware Details section of this manual, the 6502 processor is enabled from Z-80 mode by a *write* to the slot-dependent location 0EN00H, where N is the slot location of the SoftCard, Z-80 mode is selected from 6502 mode with a *write* to the same slot dependent location, which is addressed at \$CN00 in 6502 mode. (See the 6502 / Z-80 address translation table on page 2-5). Since the SoftCard may be plugged into any unused slot except zero, the location of the SoftCard will vary from system to system.

However, when the system is booted, the location of the SoftCard is determined by CP/M and its address is stored in the I/O Configuration Block. This address is thus available to CP/M software for calling 6502 subroutines. See the "Hardware Details" section of this manual.

Calling 6502 subroutines is a simple matter. The programmer simply sets up the address of the subroutine to be called, and then does a *write* to the address of the SoftCard explained above. It is also possible to pass parameters to and from 6502 subroutines through the 6502 A, X, Y, and P (status) registers. The 6502 stack pointer is also available after a 6502 subroutine call. Remember that 6502 and Z-80 addresses are not equivalent — See the 6502/Z-80 Address Translation Table on page 2-30.

| Z-80 ADDR | 6502 ADDR | PURPOSE                                                                                                                     |
|-----------|-----------|-----------------------------------------------------------------------------------------------------------------------------|
| 0F045H    | \$45      | 6502 A register pass area                                                                                                   |
| 0F046H    | \$46      | 6502 Y register pass area                                                                                                   |
| 0F047H    | \$47      | 6502 X register pass area                                                                                                   |
| 0F048H    | \$48      | 6502 P (status) register pass area                                                                                          |
| 0F049H    | \$49      | Contains 6502 stack pointer on exit from subroutine                                                                         |
| 0F3DEH    |           | Address of SoftCard held here—low byte = 0 followed by high byte of form 0ENH where N is the slot occupied by the SoftCard. |



0F3D0H

Address of 6502 subroutine to be called is stored here in low-high order.

\$3C0

Start address of 6502 to Z-80 mode switching routine. 6502 RESET, NMI, and BREAK vectors point here. A JMP to this address puts the 6502 on "hold" and returns to Z-80 mode.

**NOTE:** Locations \$800-\$FFF are NOT available for use by a 6502 subroutine. The Apple disk driver software and disk buffers reside here.

### Special Note for Language Card Users:

When in Z-80 mode, the Language Card RAM is both read- and write-enabled. When a 6502 subroutine is called, the Apple's on-board ROM is automatically enabled, making the Apple Monitor available to the 6502 subroutine. However, the Language Card RAM is write-enabled during a 6502 call, which means that a write to any location above 6502 \$D000 will write in the Language Card RAM.

A side effect of read-enabling the on-board Apple ROMs is that the Z-80 memory from 0C000H to 0EFFFH (\$D000-\$FFFF on 6502) cannot be *read* by the 6502 unless the appropriate Language Card addresses are accessed.

The first of the two available 4K banks for the 6502 \$D000-\$DFFF area is not used by Apple CP/M.

Below is a short segment of 8080 assembly language code to illustrate the use of the above addresses to call a 6502 subroutine:

```
;
; Subroutine to read the value of
; Paddle zero into register A.
; Demonstrates 6502 subroutine
; calling conventions and parameter
; passing. (NK 5/80)
;
; Equates
Z$CPU EQU 0F3DEH ;Location of SoftCard stored here
A$VEC EQU 0F3D0H ;Addr of 6502 sub. to call goes here
A$ACC EQU 0F045H ;6502 A register goes here
A$XREG EQU 0F046H ;6502 Y register pass area
PREAD EQU 0FB1EH ;Apple Monitor paddle read routine
;
PDL: XRA A ;Clear A register
      STA A$XREG ;Read paddle zero
      LXI H,PREAD ;Get addr of subroutine
      SHLD A$VEC ;And store it for 6502 caller
```

```

LHLD  Z$CPU      ;Get SoftCard addr...
MOV   M,A        ;Go do it! (Must be a write)
;
;
Execution resumes here after 6502 does a RTS
LDA   A$ACC      ;A = paddle value.
RET                               ;All done — return

```

## Indication of Presence and Location of Peripheral Cards.

### The Card Type Table

When Apple CP/M is booted, each of the slots of the Apple is checked to see if a standard Apple I/O card is installed. This is done by checking to see if there is ROM present in the slot-dependent memory space allocated to peripheral card driver ROMs, and then comparing two signature bytes to those of the standard Apple I/O peripheral cards.

This information is then stored in the Card Type Table, which is located in the I/O Configuration Block. There are seven bytes in the Card Type Table, each corresponding to the seven slots from 1 to 7.

The value of a table entry may range from 0 to 5. The meaning of each value is as follows:

| VALUE | EXPLANATION                                                                                                                          |
|-------|--------------------------------------------------------------------------------------------------------------------------------------|
| 0     | No peripheral card ROM was detected (Usually means that no card is installed in the slot)                                            |
| 1     | A peripheral card ROM was detected, but it was of an unknown type.                                                                   |
| 2     | An Apple Disk II Controller card is installed in the slot.                                                                           |
| 3     | An Apple Communications Interface or CCS 7710A Serial Interface is installed in the slot.                                            |
| 4     | An Apple High-Speed Serial Interface, Videx Videoterm, M&R Sup-R-Term or Apple Silentyte printer interface is installed in the slot. |
| 5     | An Apple Parallel Printer Interface is installed in the slot.                                                                        |

This information can be useful to the programmer. For instance, if the third entry (slot 3 — console device) of the Card Type Table is either 3 or 4, a program can assume that the user is using an 80 column external terminal of some kind. In this way, it is possible to write software that configures itself for 40 or 80 column terminals automatically.

The Card Type Table is located at 0F3B9H. The entry for a given slot is located at 3B8H + S, where S is an integer from 1 to 7.

### **Disk Count Byte**

The Disk Count Byte is a single byte equal to the number of disk controller cards in the system times two. This value does not reflect an odd number of disk drives (i.e., only one drive plugged into a controller card).

The Disk Count Byte is located at 0F3B8H.

### **To Boot a Diskette Without Powering Down**

The following program will allow you to boot diskettes from CP/M without having to turn the Apple's power off. This program *is not necessary*; it simply bypasses the power-off step.

1. Use the DDT "S" command to enter the following data at 100 hex.

```
0100 0E 01 CD 05 00 21 77 C7 22 00 30 21 00 C6 22 D0
0110 F3 2A DE F3 C3 00 30
```

2. Type Control-C to exit DDT.

3. Type SAVE 1 BOOT.COM

The program is now saved on disk. To use it, just type BOOT and press RETURN. Wait a few seconds, then insert the disk you wish to boot. Press any key to reboot the disk. Your system will reboot exactly as if you had typed PR #6 in Applesoft or Integer BASIC.



## **CHAPTER 3**

### **HARDWARE DESCRIPTION**

- **Introduction**
- **Timing Scheme**
- **SoftCard Control**
- **Address Bus Interface**
- **Data Bus Interface**
- **6502 Refresh**
- **DMA Daisy Chain**
- **Interrupts**
- **SoftCard Parts List**
- **SoftCard Schematic**

This chapter describes the SoftCard itself, both physically and operationally. You won't need this information for normal use of the SoftCard; it is included here to satisfy your curiosity and in case you have an unusual application in which this information would be needed.

## Introduction

The Microsoft SoftCard is a peripheral card for the Apple family of computers. The SoftCard contains the necessary hardware to interface a Z-80 microprocessor (contained on the card) to the Apple bus. This permits the direct execution of 8080 and Z-80 programs, including Digital Research's CP/M operating system and all of the programs written to execute in the CP/M software environment.

The SoftCard plugs into any Apple slot except slot zero, and will work in the Apple II, Apple II Plus, or either machine with the Apple Language System. When the Language System is used, the additional memory of the Language Card is made available for use by CP/M or any program operating under CP/M.

## Timing Scheme

The Z-80 microprocessor on the SoftCard is synchronized and phase locked to the Apple clocks. This is accomplished by generating a syncopated clock for the Z-80 from the Apple clocks.

During each video refresh period (01), the seven MHz Apple clock is divided down to provide three half clock periods of 135 nsec. The first half-clock is always high, the second always low, and the third always high again. After the end of the third half clock, the signal goes low and stays low until the start of the next 01. This means that the Z-80 clock is low during all of 02 plus a small part of 01. This fourth half-cycle is typically 563 nsec long. (This time is stretched by 69 nsec at the end of each video line.) The effective Z-80 clock rate is 2.041 MHz.

Each kind of machine cycle always contains one memory access period (02). The read/write line is constructed by synchronizing the leading edge of the write transition to the SoftCard clock, thus ensuring that write will only go low during the time that the SoftCard clock is high.

Because all address transitions from the Z-80 occur when its clock is high, they all must occur during 01, when the video update accesses are occurring. Therefore, each 02 cycle has stable addresses for the entire duration of the cycle.

The clock generation is performed by U4 and parts of U1 and U9. The circuit is arranged so that it will still work if the seven MHz clock occurs just prior to the start of 01, or vice-versa. Q1 and the associated components form an analog buffer to provide the high speed switching to within a few tenths of a volt of the supply voltage.

## SoftCard Control

The SoftCard is controlled by write commands to the area of memory that normally contains peripheral read-only-memory. It is important to use a write instruction to ensure that the 6502 will not perform two accesses in succession (which would prevent switching back to the 6502).

When the Apple is powered up, the Apple reset signal forces the SoftCard to the off state. The reset signal is synchronized to the Apple clocks to ensure that a write operation cannot be interrupted. The Z-80 is immediately placed in a wait mode, and remains there until the SoftCard is activated.

Upon receipt of a write to the proper area of memory, the SoftCard is activated, and the red LED is turned on. The Z-80 remains in a wait mode until one memory cycle occurs with SoftCard address information. At this point, the Z-80 is released from the wait mode and allowed to run with no further wait cycles required.

Receipt of another write to the same area of memory (this time from the SoftCard itself) will de-activate the SoftCard.

The table below shows the memory addresses used to control the SoftCard as a function of slot location:

| SLOT | CONTROL ADDRESSES |
|------|-------------------|
| 1    | \$C100-\$C1FF     |
| 2    | \$C200-\$C2FF     |
| 3    | \$C300-\$C3FF     |
| 4    | \$C400-\$C4FF     |
| 5    | \$C500-\$C5FF     |
| 6    | \$C600-\$C6FF     |
| 7    | \$C700-\$C7FF     |

## Address Bus Interface

The SoftCard address bus is interfaced to the Apple I/O bus through a bank translation circuit. This circuit, consisting of U7, U8, U11, and half of U12, resolves the memory address conflicts that exist between the 6502

architecture and the conventions used by both CP/M and the Z-80 microprocessor. When enabled by S1-1 turned off, the translator adds \$1000 to all addresses. This effectively shifts the Z-80 interrupt addresses and CP/M starting addresses out of the 6502 zero page of memory. In addition, addresses in the range of \$C000-\$EFFF are shifted to allow apparent contiguous memory for CP/M. The table below shows exactly how the translator functions:

## Z-80 ADDRESS

## APPLE ADDRESS

\$0000-\$0FFF  
 \$1000-\$1FFF  
 \$2000-\$2FFF  
 \$3000-\$3FFF  
 \$4000-\$4FFF  
 \$5000-\$5FFF  
 \$6000-\$6FFF  
 \$7000-\$7FFF  
 \$8000-\$8FFF  
 \$9000-\$9FFF  
 \$A000-\$AFFF  
 \$B000-\$BFFF  
 \$C000-\$CFFF  
 \$D000-\$DFFF  
 \$E000-\$EFFF  
 \$F000-\$FFFF

\$1000-\$1FFF  
 \$2000-\$2FFF  
 \$3000-\$3FFF  
 \$4000-\$4FFF  
 \$5000-\$5FFF  
 \$6000-\$6FFF  
 \$7000-\$7FFF  
 \$8000-\$8FFF  
 \$9000-\$9FFF  
 \$A000-\$AFFF  
 \$B000-\$BFFF  
 \$D000-\$DFFF  
 \$E000-\$EFFF  
 \$F000-\$FFFF  
 \$C000-\$CFFF  
 \$0000-\$0FFF

Notice that when the Language Card is installed, the Z-80 can address contiguous memory from \$0000-\$DFFF, without accessing the 6502 zero page of memory or the Apple peripheral area.

When the translator is disabled (S1-1 turned on) addresses presented by the Z-80 are buffered and appear at the Apple I/O bus unchanged.

All of the address buffers are tri-state buffers capable of sinking or sourcing 24 mA of current. All of the buffers are turned off whenever the SoftCard relinquishes control of the bus. The timing at turn-on and turn-off is arranged to prevent the SoftCard buffers from driving the address bus when the Apple is driving the bus.

The timing of the SoftCard forces all address transitions to occur during the time that the video display (and dynamic memory) is being refreshed by the Apple. Because for each memory access the address lines are stable at the start of the cycle, no wait states are used for memory accesses.



# Data Bus Interface

The data from the SoftCard to the Apple (memory writes) is buffered by the same high current driver type as used by the address bus interface. It is only enabled when the following two conditions occur:

1. The SoftCard has control of the bus
2. The SoftCard is attempting to write

When the SoftCard is reading memory, the data is buffered and latched by U15. The outputs of U15 are tri-state, and only enabled when the SoftCard is performing a read. The latch is needed to save data not latched by the Apple (such as the keyboard characters) until the Z-80 can look at it.

Because the SoftCard timing is synchronous and phase locked with the Apple, the timing signals generated by the Z-80 can be used to drive the buffers and the latch.

When an interrupt is recognized by the Z-80 (assuming they are enabled in both hardware and software) the pull-up resistors guarantee that a predictable response is generated for any of the interrupt modes of the Z-80. The byte of data read during an interrupt sequence will be \$FF.

## 6502 Refresh

The 6502 is a dynamic microprocessor, meaning that it requires clock cycles to maintain the contents of its internal registers. The Apple DMA circuitry interrupts operation of the 6502 by turning its clock off. Occasionally, this clock must be turned back on if the 6502 is to remain ready to operate.

This is accomplished by holding the 6502 in a non-ready state (by holding the "RDY" line low) and allowing one memory fetch to be controlled by the 6502. The data fetched is not used by the 6502, and control of the bus reverts back to the SoftCard immediately after the "refresh" memory cycle.

The Z-80 dynamic refresh control lines are used to implement this function. Therefore, the 6502 "refresh" occurs immediately after an op code fetch, and is thus transparent to the SoftCard and the user. No wait cycles have to be added to any Z-80 machine cycles, because the 6502 refresh time is used by the Z-80 to decode the op code. While the 6502 has control of the bus again, the SoftCard address and data buffers are placed in the tri-state mode.

If higher priority DMA devices are allowed to interrupt operation of the SoftCard, the 6502 refresh does not continue. Therefore if it is important to retain the register contents of the 6502 during a DMA cycle, the length of the cycle must be limited to a few microseconds (less than 5).

During a normal mixture of instructions, the 6502 refresh occurs every 4-5 microseconds, well under the data sheet maximum of 40 microseconds. The longest instruction will allow 11.25 microseconds to elapse between refreshes.

## DMA Daisy Chain

The Apple DMA daisy chain is fully supported, to the extent that a higher priority DMA device may cause the SoftCard to relinquish control of the bus. Switch S1-2 (when on) enables DMA requests to interrupt the SoftCard. If this switch is on, and the DMA daisy chain input (pin 27) is driven low, the Z-80 will finish the current machine cycle, then the SoftCard will give up control of the bus by raising the DMA control line on pin 22 of the I/O bus. At this time another device may assume control by lowering pin 22. Control must not commence sooner, because the SoftCard buffers will still be driving the bus.

If S1-2 is off, the daisy chain is preserved if the SoftCard is off. When the SoftCard is turned on, the daisy chain output (pin 24) indicates to lower priority devices that DMA activity is in progress. The lower priority devices are therefore locked out of doing any DMA. Likewise, the higher priority devices are also locked out because the SoftCard will not relinquish control of the bus.

## Interrupts

Hardware has been included to allow interrupts to be recognized by the Z-80 on the SoftCard as well as by the 6502 microprocessor. When S1-4 is on, the Z-80 will respond to interrupts occurring in the Apple. The interrupt handler program should not attempt to service the interrupt. Instead, control should be passed back to the 6502 for the actual processing. This permits the 6502, which also sees the interrupt, to clear itself of the interrupt status.

Regardless of the interrupt mode selected for the Z-80, the data byte read during the interrupt sequence will always be \$FF. This may be used to vector to a particular memory location for the interrupt handling routine.

Switch S1-3 performs the same function for the non-maskable interrupt.

## Parts List

### SoftCard

| Component Identifier | Part No. | Description  |
|----------------------|----------|--------------|
| U1                   | 74LS00   | Quad Nand    |
| U2                   | 74LS05   | Hex Inverter |
| U3                   | 74LS32   | Quad Or      |

|           |                             |                                               |
|-----------|-----------------------------|-----------------------------------------------|
| U4        | 74LS107                     | Dual Flip-Flop                                |
| U5        | 74LS74A                     | Dual Flip-Flop                                |
| U6        | 74LS74A                     | Dual Flip-Flop                                |
| U7        | 74LS86                      | Quad Ex-Or                                    |
| U8        | 74LS283                     | 4 Bit Adder                                   |
| U9        | 74LS367A                    | Hex Buffer                                    |
| U10       | Z-80A                       | Z-80A (4 MHz)                                 |
| U11       | 74LS138                     | Octal Decoder                                 |
| U12       | 74S20 (must<br>be "S" part) | Dual Nand                                     |
| U13       | 74LS367A                    | Hex Buffer                                    |
| U14       | 74LS367A                    | Hex Buffer                                    |
| U15       | 74LS373                     | Octal Latch                                   |
| U16       | 74LS367A                    | Hex Buffer                                    |
| U17       | 74LS367A                    | Hex Buffer                                    |
| Q1        | 2N3906                      | PNP Transistor                                |
| R1        |                             | 2.2K $\Omega$ , 5%, 1/4 watt                  |
| R2        |                             | 22 $\Omega$ , 5%, 1/4 watt                    |
| R3        |                             | 220 $\Omega$ , 5%, 1/4 watt                   |
| R4        |                             | 1.2K $\Omega$ , 5%, 1/4 watt                  |
| R5        |                             | 100 $\Omega$ , 5%, 1/4 watt                   |
| R6        |                             | 100 $\Omega$ , 5%, 1/4 watt                   |
| R7        |                             | 4.7K $\Omega$ , 5%, 1/4 watt                  |
| R8        |                             | 680 $\Omega$ , 5%, 1/4 watt                   |
| R9        |                             | Resistor Pack, 10K $\Omega$ ,                 |
| R10       |                             | 4.7K $\Omega$ , 5%, 1/4 watt                  |
| R11       |                             | 100 $\Omega$ , 5%, 1/4 watt                   |
| R12       |                             | 100 $\Omega$ , 5%, 1/4 watt                   |
| R13       |                             | Resistor Pack, 10K $\Omega$                   |
| C1        |                             | Capacitor, 0.05 $\mu$ F                       |
| C2        |                             | Capacitor, 0.05 $\mu$ F                       |
| C3        |                             | Capacitor, 0.05 $\mu$ F                       |
| C4        |                             | Capacitor, 47 $\rho$ F, 10%, 1000V            |
| C5        |                             | Capacitor, 0.05 $\mu$ F                       |
| C6        |                             | Capacitor, 200 $\rho$ F, 10%, 1000V           |
| C7        |                             | Capacitor, 0.05 $\mu$ F                       |
| C8        |                             | Capacitor, 200 $\rho$ F, 10%, 1000V           |
| C9        |                             | Capacitor, 0.05 $\mu$ F                       |
| C10       |                             | Capacitor, 0.05 $\mu$ F                       |
| C11       |                             | Capacitor, 0.05 $\mu$ F                       |
| C12       |                             | Capacitor, Solid Tant., 2.2 $\mu$ F, 20%, 35V |
| "Card On" |                             | Light Emitting Diode                          |
| S1        |                             | Dip Switch – Quad                             |



# **CP/M Reference Manual**

**Written by Digital Research**

**Digital Research, Post Office Box 579  
Pacific Grove, CA 93950**



# **PART 3: CP/M REFERENCE MANUAL**

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|                                         |              |
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# **CHAPTER 1**

## **INTRODUCTION TO CP/M FEATURES AND FACILITIES**

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# Introduction

CP/M is a monitor control program for microcomputer system development which uses IBM-compatible flexible disks for backup storage. Using a computer mainframe based upon Intel's 8080 microcomputer, CP/M provides a general environment for program construction, storage, and editing, along with assembly and program check-out facilities. An important feature of CP/M is that it can be easily altered to execute with any computer configuration which uses an Intel 8080 (or Zilog Z-80) Central Processing Unit, and has at least 16K bytes of main memory with up to four IBM-compatible diskette drives. Although the standard Digital Research version operates on a single-density Intel MDS 800, several different hardware manufacturers support their own input-output drivers for CP/M.

The CP/M monitor provides rapid access to programs through a comprehensive file management package. The file subsystem supports a named file structure, allowing dynamic allocation of file space as well as sequential and random file access. Using this file system, a large number of distinct programs can be stored in both source and machine executable form.

CP/M also supports a powerful context editor, Intel-compatible assembler, and debugger subsystem. Optional software includes a powerful Intel-compatible macro assembler, symbolic debugger, along with various high-level languages. When coupled with CP/M's Console Command Processor, the resulting facilities equal or excel similar large computer facilities.

CP/M is logically divided into several distinct parts:

|      |                                       |
|------|---------------------------------------|
| BIOS | Basic I/O System (hardware dependent) |
| BDOS | Basic Disk Operating System           |
| CCP  | Console Command Processor             |
| TPA  | Transient Program Area                |

**The BIOS** provides the primitive operations necessary to access the diskette drives and to interface standard peripherals (teletype, CRT, Paper Tape Reader/Punch, and user-defined peripherals), and can be tailored by the user for any particular hardware environment by "patching" this portion of CP/M.

**The BDOS** provides disk management by controlling one or more disk drives containing independent file directories. The BDOS implements disk allocation strategies which provide fully dynamic file construction while

minimizing head movement across the disk during access. Any particular file may contain any number of records, not exceeding the size of any single disk. In a standard CP/M system, each disk can contain up to 64 distinct files. The BDOS has entry points which include the following primitive operations which can be programmatically accessed:

|        |                                                        |
|--------|--------------------------------------------------------|
| SEARCH | Look for a particular disk file by name.               |
| OPEN   | Open a file for further operations.                    |
| CLOSE  | Close a file after processing.                         |
| RENAME | Change the name of a particular file.                  |
| READ   | Read a record from a particular file.                  |
| WRITE  | Write a record onto the disk.                          |
| SELECT | Select a particular disk drive for further operations. |

**The CCP** provides symbolic interface between the user's console and the remainder of the CP/M system. The CCP reads the console device and processes commands which include listing the file directory, printing the contents of files, and controlling the operation of transient programs, such as assemblers, editors, and debuggers. The standard commands which are available in the CCP are listed in a following section.

The last segment of CP/M is the area called the Transient Program Area (TPA). **The TPA** holds programs which are loaded from the disk under command of the CCP. During program editing, for example, the TPA holds the CP/M text editor machine code and data areas. Similarly, programs created under CP/M can be checked out by loading and executing these programs in the TPA.

It should be mentioned that any or all of the CP/M component subsystems can be "overlaid" by an executing program. That is, once a user's program is loaded into the TPA, the CCP, BDOS, and BIOS areas can be used as the program's data area. A "bootstrap" loader is programmatically accessible whenever the BIOS portion is not overlaid; thus, the user program need only branch to the bootstrap loader at the end of execution, and the complete CP/M monitor is reloaded from disk.

It should be reiterated that the CP/M operating system is partitioned into distinct modules, including the BIOS portion which defines the hardware environment in which CP/M is executing. Thus, the standard system can be

easily modified to any non-standard environment by changing the peripheral drivers to handle the custom system.

## **An Overview of CP/M 2.0 Facilities**

CP/M 2.0 is a high-performance single-console operating system which uses table driven techniques to allow field configuration to match a wide variety of disk capacities. All of the fundamental file restrictions are removed, while maintaining upward compatibility from previous versions of release 1. Features of CP/M 2.0 include field specification of one to sixteen logical drives, each containing up to eight megabytes. Any particular file can reach the full drive size with the capability to expand to thirty-two megabytes in future releases. The directory size can be field configured to contain any reasonable number of entries, and each file is optionally tagged with read/only and system attributes. Users of CP/M 2.0 are physically separated by user numbers, with facilities for file copy operations from one user area to another. Powerful relative-record random access functions are present in CP/M 2.0 which provide direct access to any of the 65536 records of an eight megabyte file.

All disk-dependent portions of CP/M 2.0 are placed into a BIOS-resident "disk parameter block" which is either hand coded or produced automatically using the disk definition macro library provided with CP/M 2.0. The end user need only specify the maximum number of active disks, the starting and ending sector numbers, the data allocation size, the maximum extent of the logical disk, directory size information, and reserved track values. The macros use this information to generate the appropriate tables and table references for use during CP/M 2.0 operation. Deblocking information is also provided which aids in assembly or disassembly of sector sizes which are multiples of the fundamental 128 byte data unit, and the system alteration manual includes general-purpose subroutines which use this deblocking information to take advantage of larger sector sizes. Use of these subroutines, together with the table driven data access algorithms, make CP/M 2.0 truly a universal data management system.

File expansion is achieved by providing up to 512 logical file extents, where each logical extent contains 16K bytes of data. CP/M 2.0 is structured, however, so that as much as 128K bytes of data is addressed by a single physical extent (corresponding to a single directory entry), thus maintaining compatibility with previous versions while taking full advantage of directory space.

Random access facilities are present in CP/M 2.0 which allow immediate reference to any record of an eight megabyte file. Using CP/M's unique data organization, data blocks are only allocated when actually required and movement to a record position requires little search time. Sequential file access is upwardly compatible from earlier versions to the full eight

megabytes, while random access compatibility stops at 512K byte files. Due to CP/M 2.0's simpler and faster random access, application programmers are encouraged to alter their programs to take full advantage of the 2.0 facilities.

Several CP/M 2.0 modules and utilities have improvements which correspond to the enhanced file system. STAT and PIP both account for file attributes and user areas, while the CCP provides a "login" function to change from one user area to another. The CCP also formats directory displays in a more convenient manner and accounts for both CRT and hard-copy devices in its enhanced line editing functions.

## Functional Description of CP/M

The user interacts with CP/M primarily through the CCP, which reads and interprets commands entered through the console. In general, the CCP addresses one of several disks which are online (the standard system addresses up to four different disk drives). These disk drives are labelled A, B, C, and D. A disk is "logged in" if the CCP is currently addressing the disk. In order to clearly indicate which disk is the currently logged disk, the CCP always prompts the operator with the disk name followed by the symbol ">" indicating that the CCP is ready for another command. Upon initial start up, the CP/M system is brought in from disk A, and the CCP displays the message

xxK CP/M VER m.m

where xx is the memory size (in kilobytes) which this CP/M system manages, and m.m is the CP/M version number. All CP/M systems are initially set to operate in a 16K memory space, but can be easily reconfigured to fit any memory size on the host system. Following system signon, CP/M automatically logs in disk A, prompts the user with the symbol "A>" (indicating that CP/M is currently addressing disk "A"), and waits for a command. The commands are implemented at two levels: built-in commands and transient commands.

## General Command Structure

Built-in commands are a part of the CCP program itself, while transient commands are loaded into the TPA from disk and executed. The built-in commands are

|     |                                       |
|-----|---------------------------------------|
| ERA | Erase specified files.                |
| DIR | Displays file names in the directory. |



|             |                                                 |
|-------------|-------------------------------------------------|
| <b>REN</b>  | Rename the specified file.                      |
| <b>SAVE</b> | Save memory contents in a file.                 |
| <b>TYPE</b> | Type the contents of a file on the logged disk. |
| <b>USER</b> | Move to another area within the same directory. |

Nearly all of the commands reference a particular file or group of files. The form of a file reference is specified below.

## File References

A file reference identifies a particular file or group of files on a particular disk attached to CP/M. These file references can be either "unambiguous" (ufn) or "ambiguous" (afn). An unambiguous file reference uniquely identifies a single file, while an ambiguous file reference may be satisfied by a number of different files.

File references consist of two parts: the primary name and the secondary name. Although the secondary name is optional, it usually is generic; that is, the secondary name "ASM," for example, is used to denote that the file is an assembly language source file, while the primary name distinguishes each particular source file. The two names are separated by a "." as shown below:

pppppppp.sss

where pppppppp represents the primary name of eight characters or less, and sss is the secondary name of no more than three characters. As mentioned above, the name

pppppppp

is also allowed and is equivalent to a secondary name consisting of three blanks. The characters used in specifying an unambiguous file reference cannot contain any of the special characters

< > . , ; : = ? \* [ ]

while all alphanumerics and remaining special characters are allowed.

An ambiguous file reference is used for directory search and pattern matching. The form of an ambiguous file reference is similar to an unambiguous reference, except the symbol "?" may be interspersed throughout the primary and secondary names. In various commands throughout CP/M, the "?" symbol matches any character of a file name in the "?" position. Thus, the ambiguous reference

X?Z.C?M

is satisfied by the unambiguous file names

XYZ.COM

and

X3Z.CAM

Note that the ambiguous reference

\*.\*

is equivalent to the ambiguous file reference

????????.???

while

pppppppp.\*

and

\*.sss

are abbreviations for

pppppppp.???

and

????????.sss

respectively. As an example,

DIR \*.\*

is interpreted by the CCP as a command to list the names of all disk files in the directory, while

DIR X.Y

searches only for a file by the name X.Y. Similarly, the command

DIR X?Y.C?M

causes a search for all (unambiguous) file names on the disk which satisfy this ambiguous reference.

The following file names are valid unambiguous file references:

|     |         |         |
|-----|---------|---------|
| X   | XYZ     | GAMMA   |
| X.Y | XYZ.COM | GAMMA.1 |

As an added convenience, the programmer can generally specify the disk drive name along with the file name. In this case, the drive name is given as a letter A through Z followed by a colon (:). The specified drive is then "logged in" before the file operation occurs. Thus, the following are valid file names with disk name prefixes:

|           |         |         |
|-----------|---------|---------|
| A:X.Y     | B:XYZ   | C:GAMMA |
| Z:XYZ.COM | B:X.A?M | C:*.ASM |

It should also be noted that all alphabetic lower case letters in file and drive names are always translated to upper case when they are processed by the CCP.

## Switching Disks

The operator can switch the currently logged disk by typing the disk drive name (A, B, C, or D) followed by a colon (:) when the CCP is waiting for console input. Thus, the sequence of prompts and commands shown below might occur after the CP/M system is loaded from disk A:

|                  |                            |
|------------------|----------------------------|
| 16K CP/M VER 1.4 |                            |
| A>DIR            | List all files on disk A.  |
| SAMPLE ASM       |                            |
| SAMPLE PRN       |                            |
| A>B:             | Switch to disk B.          |
| B>Dir *.ASM      | List all "ASM" files on B. |
| DUMP ASM         |                            |
| FILES ASM        |                            |
| B>A:             | Switch back to A.          |

## Form of Built-In Commands

The file and device reference forms described above can now be used to fully specify the structure of the built-in commands. In the description below, assume the following abbreviations:

|     |                            |
|-----|----------------------------|
| ufn | unambiguous file reference |
| afn | ambiguous file reference   |
| cr  | carriage return            |

Further, recall that the CCP always translates lower case characters to

upper case characters internally. Thus, lower case alphabets are treated as if they are upper case in command names and file references.

## **ERASE Command**

### **ERA afn**

The ERA (erase) command removes files from the currently logged-in disk (i.e., the disk name currently prompted by CP/M preceding the ">"). The files which are erased are those which satisfy the ambiguous file reference afn. The following examples illustrate the use of ERA:

- |             |                                                                                                                                                                                          |
|-------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| ERA X.Y     | The file named X.Y on the currently logged disk is removed from the disk directory, and the space is returned.                                                                           |
| ERA X.*     | All files with primary name X are removed from the current disk.                                                                                                                         |
| ERA *.ASM   | All files with secondary name ASM are removed from the current disk.                                                                                                                     |
| ERA X?Y.C?M | All files on the current disk which satisfy the ambiguous reference X?Y.C?M are deleted.                                                                                                 |
| ERA *.*     | Erase all files in the current user's directory. (See USER n, page 13.) The CCP prompts with the message<br>ALL (Y/N)?<br>which requires a Y response before files are actually removed. |
| ERA B:*.PRN | All files on drive B which satisfy the ambiguous reference ???????.PRN are deleted, independently of the currently logged disk.                                                          |

## **DIRectory Command**

### **DIR afn**

The DIR (directory) command causes the names of all files which satisfy the ambiguous file name afn to be listed at the console device. As a special case, the command

### **DIR**

lists the files on the currently logged disk (the command "DIR" is equivalent to the command "DIR \*.\*"). Valid DIR commands are shown below.

DIR X.Y

DIR X?Z.C?M

DIR ??Y

Similar to other CCP commands, the afn can be preceded by a drive name. The following DIR commands cause the selected drive to be addressed before the directory search takes place.

DIR B:

DIR B:X.Y

DIR B:\*.A?M

If no files can be found on the selected diskette which satisfy the directory request, then the message "NOT FOUND" is typed at the console.

### **REName Command**

REN ufn2 = ufn1

The REN (rename) command allows the user to change the names of files on disk. The file satisfying ufn2 is changed to ufn1. The currently logged disk is assumed to contain the file to rename (ufn1). The CCP also allows the user to type a left-directed arrow instead of the equal sign, if the user's console supports this graphic character. Examples of the REN command are

REN X.Y=Q.R                      The file Q.R is changed to X.Y.

REN XYZ.COM=XYZ.XXX            The file XYZ.XXX is changed to  
XYZ.COM.

The operator can precede either ufn1 or ufn2 (or both) by an optional drive address. Given that ufn1 is preceded by a drive name, then ufn2 is assumed to exist on the same drive as ufn1. Similarly, if ufn2 is preceded by a drive name, then ufn1 is assumed to reside on that drive as well. If both ufn1 and ufn2 are preceded by drive names, then the same drive must be specified in both cases. The following REN commands illustrate this format.

REN A:X.ASM = Y.ASM            The file Y.ASM is changed to X.ASM  
on drive A.

REN B:ZAP.BAS=ZOT.BAS           The file ZOT.BAS is changed to  
ZAP.BAS on drive B.

**REN B:A.ASM = B:A.BAK**

The file A.BAK is renamed to A.ASM on drive B.

If the file ufn1 is already present, the REN command will respond with the error "FILE EXISTS" and not perform the change. If ufn2 does not exist on the specified diskette, then the message "NOT FOUND" is printed at the console.

## **SAVE Command**

**SAVE n ufn**

The SAVE command places n pages (256-byte blocks) onto disk from the TPA and names this file ufn. In the CP/M distribution system, the TPA starts at 100H (hexadecimal), which is the second page of memory. Thus, if the user's program occupies the area from 100H through 2FFH, the SAVE command must specify two pages of memory. The machine code file can be subsequently loaded and executed. Examples are:

**SAVE 3 X.COM**

Copies 100H through 3FFH to X.COM.

**SAVE 40 Q**

Copies 100H through 28FFH to Q (note that 28 is the page count in 28FFH, and that  $28H = 2 \times 16 + 8 = 40$  decimal).

**SAVE 4 X.Y**

Copies 100H through 4FFH to X.Y.

The SAVE command can also specify a disk drive in the afn portion of the command, as shown below.

**SAVE 10 B:ZOT.COM**

Copies 10 pages (100H through 0AFFH) to the file ZOT.COM on drive B.

The SAVE operation can be used any number of times without altering the memory image.

## **TYPE Command**

**TYPE ufn**

The TYPE command displays the contents of the ASCII source file ufn on the currently logged disk at the console device. Valid TYPE commands are

**TYPE X.Y**

**TYPE X.PLM**

**TYPE XXX**

The **TYPE** command expands tabs (clt-I characters), assuming tab positions are set at every eighth column. The ufn can also reference a drive name as shown below.

**TYPE B:X.PRN** The file X.PRN from drive B is displayed.

## **USER Command**

**USER n**

Where n is an integer value in the range 0 to 15.

Upon cold start, the operator is automatically “logged” into user area number 0. The operator may issue the **USER** command at any time to move to another logical area within the same directory.

Drives which are logged in while addressing one user number are automatically active when the operator moves to another user number since a user number is simply a prefix which accesses particular directory entries on the active disks.

The active user number is maintained until changed by a subsequent **USER** command, or until a cold start operation when user 0 is again assumed.

## **Line Editing and Output Control**

The CCP allows certain line editing functions while typing command lines. “Control” indicates that the Control key and the indicated key are to be pressed simultaneously. CCP commands can generally be up to 255 characters in length; they are not acted upon until the carriage return key is pressed.

|               |                                                                                                              |
|---------------|--------------------------------------------------------------------------------------------------------------|
| rubout/delete | Remove and echo last character typed                                                                         |
| Control C     | Reboot CP/M when at beginning of line                                                                        |
| Control E     | Physical end of line: carriage is returned, but line is not sent until the carriage return key is depressed. |

|           |                                                                                                                                                                                   |
|-----------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Control H | Backspace one character position. Produces the backspace overwrite function. Can be changed internally to another character, such as delete, through a simple single byte change. |
| Control J | Line feed. Terminates current input.                                                                                                                                              |
| Control M | Carriage return. Terminates input.                                                                                                                                                |
| Control R | Retype current command line after new line.                                                                                                                                       |
| Control X | Backspace to beginning of current line.                                                                                                                                           |

The line editor keeps track of the current prompt column position so that the operator can properly align data input following a Control R or Control X command.

The control functions Control P and Control S affect console output as shown below.

|           |                                                                                                                                                                                                                                                                                          |
|-----------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Control P | Copy all subsequent console output to the currently assigned list device (see the STAT command). Output is sent to both the list device and the console device until the next Control P is typed.                                                                                        |
| Control S | Stop the console output temporarily. Program execution and output continue when the next character is typed at the console (e.g., another Control S). This feature is used to stop output on high speed consoles, such as CRT's, in order to view a segment of output before continuing. |

## Transient Commands

Transient commands are loaded from the currently logged disk and executed in the TPA. The transient commands defined for execution under the CCP are shown below. Additional functions can easily be defined by the user (see the LOAD command definition).

|      |                                                                                                                                                                             |
|------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| STAT | List the number of bytes of storage remaining on the currently logged disk, provide statistical information about particular files, and display or alter device assignment. |
| ASM  | Load the CP/M assembler and assemble the specified program from disk.                                                                                                       |



|               |                                                                                                                                                                                            |
|---------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>LOAD</b>   | Load the file in Intel "hex" machine code format and produce a file in machine executable form which can be loaded into the TPA (this loaded program becomes a new command under the CCP). |
| <b>DDT</b>    | Load the CP/M debugger into TPA and start execution.                                                                                                                                       |
| <b>PIP</b>    | Load the Peripheral Interchange Program for subsequent disk file and peripheral transfer operations.                                                                                       |
| <b>ED</b>     | Load and execute the CP/M text editor program.                                                                                                                                             |
| <b>SUBMIT</b> | Submit a file of commands for batch processing.                                                                                                                                            |
| <b>DUMP</b>   | Dump the contents of a file in hex.                                                                                                                                                        |

Transient commands are specified in the same manner as built-in commands, and additional commands can be easily defined by the user. As an added convenience, the transient command can be preceded by a drive name, which causes the transient to be loaded from the specified drive into the TPA for execution. Thus, the command

**B:STAT**

causes CP/M to temporarily "log in" drive B for the source of the STAT transient, and then return to the original logged disk for subsequent processing.

The basic transient commands are listed in detail below.

## **STAT**

The STAT command provides general statistical information about file storage and device assignment. It is initiated by typing one of the following forms:

STAT  
STAT "command line"

Special forms of the "command line" allow the current device assignment to be examined and altered as well. The various command lines which can be specified are shown below, with an explanation of each form shown to the right.

STAT <cr>

If the user types an empty command line, the STAT transient calculates the storage remaining on all active drives, and prints a message

x: R/W, SPACE: nnnK  
or  
x: R/O, SPACE: nnnK

for each active drive x, where R/W indicates the drive may be read or written, and R/O indicates the drive is read only (a drive becomes R/O by explicitly setting it to read only, as shown below, or by inadvertently changing diskettes without performing a warm start). The space remaining on the diskette in drive x is given in kilobytes by nnn.

STAT x: <cr>

If a drive name is given, then the drive is selected before the storage is computed. Thus, the command "STAT B:" could be issued while logged into drive A, resulting in the message

BYTES REMAINING ON B: nnnK

STAT afn <cr>

The command line can also specify a set of files to be scanned by STAT. The files which satisfy afn are listed in alphabetical order, with storage requirements for each file under the heading

| RECS | BYTS | EX | D:FILENAME.TYP |
|------|------|----|----------------|
| rrrr | bbbK | ee | d:pppppppp.sss |

where rrrr is the number of 128-byte records allocated to the file, bbb is the number of kilobytes allocated to the file ( $bbb = rrrr * 128 / 1024$ ), ee is the number of 16K extensions ( $ee = bbb / 16$ ), d is the drive name containing the file (A...Z), pppppppp is the (up to) eight-character primary file name, and sss is the (up to) three-character secondary name. After listing the individual files, the storage usage is summarized.

STAT x:afn <cr>

As a convenience, the drive name can be given ahead of the afn. In this case, the specified drive is first selected, and the form "STAT afn" is executed.

STAT d:filename.typ \$\$ <cr>

("d:" is optional drive name and "filename.typ" is an unambiguous or ambiguous file name)

Produces the output display format:

| Size  | Recs | Bytes | Ext | Acc             |
|-------|------|-------|-----|-----------------|
| 48    | 48   | 6K    | 1   | R/O A:ED.COM    |
| 55    | 55   | 12K   | 1   | R/O (A:PIP.COM) |
| 65536 | 128  | 2K    | 2   | R/W A:X.DAT     |

The \$\$ parameter causes the "Size" field to be displayed. (The command may be used without the \$\$ if desired.) The Size field lists the virtual file size in records, while the "Recs" field sums the number of virtual records in each extent. For files constructed sequentially, the Size and Recs fields are identical. The "Bytes" field lists the actual number of bytes allocated to the corresponding file. The minimum allocation unit is determined at configuration time, and thus the number of bytes corresponds to the record count plus the remaining unused space in the last allocated block for sequential files. Random access files are given data areas only when written, so the Bytes field contains the only accurate allocation figure. In the case of random access, the Size field gives the logical end-of-file record position and the Recs field counts the logical records of each extent (each of these extents, however, may contain unallocated "holes" even though they are added into the record count). The "Ext" field counts the number of local 16K extents allocated to the file. The "Acc" field gives the R/O or R/W access mode, which is changed using the commands shown below. The parentheses shown around the PIP.COM file name indicate that it has the "system" indicator set, so that it will not be listed in DIR commands.

STAT d:filename.typ \$R/O <cr>

Places the file or set of files in a read-only status until changed by a subsequent STAT command. The R/O status is recorded in the directory with the file so that it remains R/O through intervening cold start operations. When a file is marked R/O, attempts to erase or write into the file result in a terminal BDOS message: Bdos Err on D: File R/O.

STAT d:filename.typ \$R/W <cr>

Places the file in a permanent read/write status.

**STAT d:filename.typ \$SYS <cr>**  
Attaches the system indicator to the file.

**STAT d:filename.typ \$DIR <cr>**  
Removes the system indicator from the file.

**STAT d:DSK: <cr>**  
Lists the drive characteristics of the disk named by "d:" which is in the range A:, B:, ..., P:. The drive characteristics are listed in the format:

|        |                           |
|--------|---------------------------|
| d:     | Drive Characteristics     |
| 65536: | 128 Byte Record Capacity  |
| 8192:  | Kilobyte Drive Capacity   |
| 128:   | 32 Byte Directory Entries |
| 0:     | Checked Directory Entries |
| 1024:  | Records/Extent            |
| 128:   | Records/Block             |
| 58:    | Sectors/Track             |
| 2:     | Reserved Tracks           |

The total record capacity is listed, followed by the total drive capacity listed in Kbytes. The number of checked entries is usually identical to the directory size for removable media, since this mechanism is used to detect changed media during CP/M operation without an intervening warm start. The number of records per extent determines the addressing capacity of each directory entry (1024 times 128 bytes, or 128K in the example above). The number of records per block shows the basic allocation size (in the example, 128 records/block times 128 bytes per record, or 16K bytes per block). The listing is then followed by the number of physical sectors per track and the number of reserved tracks.

**STAT DSK: <cr>**  
Lists drive characteristics as above for all currently active drives.

**STAT USR: <cr>**  
Produces a list of the user numbers which have files on the currently addressed disk. The display format is:

Active User : 0  
Active Files: 0 1 3

where the first line lists the currently addressed user number, as set by the last CCP USER command, followed by a list of user numbers scanned from the current directory. In the above case, the active user number is 0 (default at cold start), with three user numbers which have

active files on the current disk. The operator can subsequently examine the directories of the other user numbers by logging in with USER 1, USER 2, or USER 3 commands, followed by a DIR command at the CCP level.

The STAT command also allows control over the physical to logical device assignment (see the IOBYTE function described in the "CP/M Interface Guide." In general, there are four logical peripheral devices which are, at any particular instant, each assigned to one of several physical peripheral devices. The four logical devices are named:

|      |                                                                             |
|------|-----------------------------------------------------------------------------|
| CON: | The system console device (used by CCP for communication with the operator) |
| RDR: | The paper tape reader device                                                |
| PUN: | The paper tape punch device                                                 |
| LST: | The output list device                                                      |

The actual devices attached to any particular computer system are driven by subroutines in the BIOS portion of CP/M. Thus, the logical RDR: device, for example, could actually be a high speed reader, Teletype reader, or cassette tape. In order to allow some flexibility in device naming and assignment, several physical devices are defined, as shown below:

|      |                                                                                |
|------|--------------------------------------------------------------------------------|
| TTY: | Teletype device (slow speed console)                                           |
| CRT: | Cathode ray tube device (high speed console)                                   |
| BAT: | Batch processing (console is current RDR:, output goes to current LST: device) |
| UC1: | User-defined console                                                           |
| PTR: | Paper tape reader (high speed reader)                                          |
| UR1: | User-defined reader #1                                                         |
| UR2: | User-defined reader #2                                                         |
| PTP: | Paper tape punch (high speed punch)                                            |
| UP1: | User-defined punch #1                                                          |

|      |                             |
|------|-----------------------------|
| UP2: | User-defined punch #2       |
| LPT: | Line printer                |
| UL1: | User-defined list device #1 |

It must be emphasized that the physical device names may or may not actually correspond to devices which the names imply. That is, the PTP: device may be implemented as a cassette write operation, if the user wishes. The exact correspondence and driving subroutine is defined in the BIOS portion of CP/M. In the standard distribution version of CP/M, these devices correspond to their names on the MDS 800 development system.

The command:

STAT VAL: <cr>

produces a summary of the available status commands, resulting in the output:

Temp R/O Disk: d: = R/O

Set Indicator: d:filename.typ \$R/O \$R/W \$SYS \$DIR

Disk Status: DSK: d:DSK:

User Status: USR:

Iobyte Assign:

|             |      |      |      |
|-------------|------|------|------|
| CON. = TTY: | CRT: | BAT: | UC1: |
| RDR: = TTY: | PTR: | UR1: | UR2: |
| PUN: = TTY: | PTP: | UP1: | UP2: |
| LST: = TTY: | CRT: | LPT: | UL1: |

In each case, the logical device shown to the left can take any of the four physical assignments shown to the right on each line. The current logical to physical mapping is displayed by typing the command

STAT DEV: <cr>

which produces a listing of each logical device to the left, and the current corresponding physical device to the right. For example, the list might appear as follows:

CON: = CRT:  
RDR: = UR1:  
PUN: = PTP:  
LST: = TTY:

The current logical to physical device assignment can be changed by typing a STAT command of the form

STAT ld1 = pd1, ld2 = pd2 , ... , ldn = pdn <cr>

where ld1 through ldn are logical device names, and pd1 through pdn are compatible physical device names (i.e., ldi and pdi appear on the same line in the "VAL:" command shown above). The following are valid STAT commands which change the current logical to physical device assignments:

STAT CON: = CRT: <cr>  
STAT PUN: = TTY:, LST: = LPT:, RDR: = TTY: <cr>

### **ASM ufn**

The ASM command loads and executes the CP/M 8080 assembler. The ufn specifies a source file containing assembly language statements where the secondary name is assumed to be ASM, and thus is not specified. The following ASM commands are valid:

ASM X

ASM GAMMA

The two-pass assembler is automatically executed. If assembly errors occur during the second pass, the errors are printed at the console.

The assembler produces a file

x.PRN

where x is the primary name specified in the ASM command. The PRN file contains a listing of the source program (with imbedded tab characters if present in the source program), along with the machine code generated for each statement and diagnostic error messages, if any. The PRN file can be listed at the console using the TYPE command, or sent to a peripheral device using PIP (see the PIP command structure below). Note also that the PRN file contains the original source program, augmented by miscellaneous assembly information in the leftmost 16 columns (program addresses and hexadecimal machine code, for example). Thus, the PRN file can serve as a

backup for the original source file: if the source file is accidentally removed or destroyed, the PRN file can be edited (see the ED operator's guide) by removing the leftmost 16 characters of each line (this can be done by issuing a single editor "macro" command). The resulting file is identical to the original source file and can be renamed (REN) from PRN to ASM for subsequent editing and assembly. The file

**x.HEX**

is also produced which contains 8080 machine language in Intel "hex" format suitable for subsequent loading and execution (see the LOAD command). For complete details of CP/M's assembly language program, see the "CP/M Assembler Language (ASM) User's Guide."

Similar to other transient commands, the source file for assembly can be taken from an alternate disk by prefixing the assembly language file name by a disk drive name. Thus, the command

**ASM B:ALPHA <cr>**

loads the assembler from the currently logged drive and operates upon the source program ALPHA.ASM on drive B. The HEX and PRN files are also placed on drive B in this case.

### **LOAD ufn cr**

The LOAD command reads the file ufn, which is assumed to contain "hex" format machine code, and produces a memory image file which can be subsequently executed. The file name ufn is assumed to be of the form

**x.HEX**

and thus only the name x need be specified in the command. The LOAD command creates a file named

**x.COM**

which marks it as containing machine executable code. The file is actually loaded into memory and executed when the user types the file name x immediately after the prompting character ">" printed by the CCP.

In general, the CCP reads the name x following the prompting character and looks for a built-in function name. If no function name is found, the CCP searches the system disk directory for a file by the name



## x.COM

If found, the machine code is loaded into the TPA, and the program executes. Thus, the user need only LOAD a hex file once; it can be subsequently executed any number of times by simply typing the primary name. In this way, the user can "invent" new commands in the CCP. (Initialized disks contain the transient commands as COM files, which can be deleted at the user's option.) The operation can take place on an alternate drive if the file name is prefixed by a drive name. Thus

### LOAD B:BETA

brings the LOAD program into the TPA from the currently logged disk and operates upon drive B after execution begins.

It must be noted that the BETA.HEX file must contain valid Intel format hexadecimal machine code records (as produced by the ASM program, for example) which begin at 100H, the beginning of the TPA. Further, the addresses in the hex records must be in ascending order; gaps in unfilled memory regions are filled with zeroes by the LOAD command as the hex records are read. Thus, LOAD must be used only for creating CP/M standard "COM" files which operate in the TPA. Programs which occupy regions of memory other than the TPA can be loaded under DDT.

## PIP

PIP is the CP/M Peripheral Interchange Program which implements the basic media conversion operations necessary to load, print, punch, copy, and combine disk files. The PIP program is initiated by typing one of the following forms

PIP <cr>  
PIP "command line" <cr>

In both cases, PIP is loaded into the TPA and executed. In case 1, PIP reads command lines directly from the console, prompted with the "\*" character, until an empty command line is typed (i.e., a single carriage return is issued by the operator). Each successive command line causes some media conversion to take place according to the rules shown below. Form 2 of the PIP command is equivalent to the first, except that the single command line given with the PIP command is automatically executed, and PIP terminates immediately with no further prompting of the console for input command lines. The form of each command line is

destination = source #1, source #2, ... , source #n <cr>

where "destination" is the file or peripheral device to receive the data, and "source #1, ..., source #n" represents a series of one or more files or devices which are copied from left to right to the destination.

When multiple files are given in the command line (i.e.,  $n > 1$ ), the individual files are assumed to contain ASCII characters, with an assumed CP/M end-of-file character (ctl-Z) at the end of each file (see the O parameter to override this assumption). The equal symbol (=) can be replaced by a left-oriented arrow, if your console supports this ASCII character, to improve readability. Lower case ASCII alphabets are internally translated to upper case to be consistent with CP/M file and device name conventions. Finally, the total command line length cannot exceed 255 characters (ctl-E can be used to force a physical carriage return for lines which exceed the console width).

The destination and source elements can be unambiguous references to CP/M source files, with or without a preceding disk drive name. That is, any file can be referenced with a preceding drive name (A:, B:, C:, or D:) which defines the particular drive where the file may be obtained or stored. When the drive name is not included, the currently logged disk is assumed. Further, the destination file can also appear as one or more of the source files, in which case the source file is not altered until the entire concatenation is complete. If the destination file already exists, it is removed if the command line is properly formed (it is not removed if an error condition arises). The following command lines (with explanations to the right) are valid as input to PIP:

|                               |                                                                                            |
|-------------------------------|--------------------------------------------------------------------------------------------|
| <code>X = Y &lt;cr&gt;</code> | Copy to file X from file Y, where X and Y are unambiguous file names; Y remains unchanged. |
|-------------------------------|--------------------------------------------------------------------------------------------|

|                                 |                                                                       |
|---------------------------------|-----------------------------------------------------------------------|
| <code>X = Y,Z &lt;cr&gt;</code> | Concatenate files Y and Z and copy to file X, with Y and Z unchanged. |
|---------------------------------|-----------------------------------------------------------------------|

|                                                     |                                                                                        |
|-----------------------------------------------------|----------------------------------------------------------------------------------------|
| <code>X.ASM = Y.ASM,Z.ASM,FIN.ASM &lt;cr&gt;</code> | Create the file X.ASM from the concatenation of the Y, Z, and FIN files with type ASM. |
|-----------------------------------------------------|----------------------------------------------------------------------------------------|

|                                             |                                                                                          |
|---------------------------------------------|------------------------------------------------------------------------------------------|
| <code>NEW.ZOT = B:OLD.ZAP &lt;cr&gt;</code> | Move a copy of OLD.ZAP from drive B to the currently logged disk; name the file NEW.ZOT. |
|---------------------------------------------|------------------------------------------------------------------------------------------|

|                                                  |                                                                                                                        |
|--------------------------------------------------|------------------------------------------------------------------------------------------------------------------------|
| <code>B:A.U. = B:B.V,A:C.W,D.X &lt;cr&gt;</code> | Concatenate file B.V from drive B with C.W from drive A and D.X. from the logged disk; create the file A.U on drive B. |
|--------------------------------------------------|------------------------------------------------------------------------------------------------------------------------|

For more convenient use, PIP allows abbreviated commands for transferring files between disk drives. The abbreviated forms are

PIP x: = afn <cr>

PIP x: = y:afn <cr>

PIP ufn = y: <cr>

PIP x:ufn = y: <cr>

The first form copies all files from the currently logged disk which satisfy the afn to the same file names on drive x (x = A...Z). The second form is equivalent to the first, where the source for the copy is drive y (y = A...Z). The third form is equivalent to the command "PIP ufn = y:ufn <cr>" which copies the file given by ufn from drive y to the file ufn on drive x. The fourth form is equivalent to the third, where the source disk is explicitly given by y.

Note that the source and destination disks must be different in all of these cases. If an afn is specified, PIP lists each ufn which satisfies the afn as it is being copied. If a file exists by the same name as the destination file, it is removed upon successful completion of the copy, and replaced by the copied file.

The following PIP commands give examples of valid disk-to-disk copy operations:

B: = \*.COM <cr>                      Copy all files which have the secondary name "COM" to drive B from the current drive.

A: = B:ZAP.\* <cr>                      Copy all files which have the primary name "ZAP" to drive A from drive B.

ZAP.ASM = B: <cr>                      Equivalent to ZAP.ASM = B:ZAP.ASM

B:ZOT.COM = A: <cr>                      Equivalent to B:ZOT.COM = A:ZOT.COM

B: = GAMMA.BAS <cr>                      Same as B:GAMMA.BAS = GAMMA.BAS

B: = A:GAMMA.BAS <cr>                      Same as  
B:GAMMA.BAS = A:GAMMA.BAS

PIP also allows reference to physical and logical devices which are attached to the CP/M system. The device names are the same as given under the STAT command, along with a number of specially named devices. The logical

devices given in the STAT command are

CON: (console), RDR: (reader), PUN: (punch), and LST: (list)

while the physical devices are

TTY: (console, reader, punch, or list)

CRT: (console, or list), UC1: (console

PTR: (reader), UR1: (reader), UR2: (reader)

PTP: (punch), UP1: (punch), UP2: (punch)

LPT: (list), UL1: (list)

(Note that the "BAT:" physical device is not included, since this assignment is used only to indicate that the RDR: and LST: devices are to be used for console input/output.)

The RDR, LST, PUN, and CON devices are all defined within the BIOS portion of CP/M, and thus are easily altered for any particular I/O system. (The current physical device mapping is defined by IOBYTE; see the "CP/M Interface Guide" for a discussion of this function). The destination device must be capable of receiving data (i.e., data cannot be sent to the punch), and the source devices must be capable of generating data (i.e., the LST: device cannot be read).

The additional device names which can be used in PIP commands are

NUL: Send 40 "nulls" (ASCII 0's) to the device (this can be issued at the end of punched output).

EOF: Send a CP/M end-of-file (ASCII ctl-Z) to the destination device (sent automatically at the end of all ASCII data transfers through PIP).

INP: Special PIP input source which can be "patched" into the PIP program itself: PIP gets the input data character-by-character by CALLing location 103H, with data returned in location 109H (parity bit must be zero).

OUT: Special PIP output destination which can be patched into the PIP program: PIP CALLs location 106H with data in register C for each character to transmit. Note that locations 109H through 1FFH of the PIP memory image are not used and can be replaced by special purpose drivers using DDT (see the DDT operator's manual).

PRN: Same as LST:, except that tabs are expanded at every eighth

character position, lines are numbered, and page ejects are inserted every 60 lines, with an initial eject (same as [t8np]).

File and device names can be interspersed in the PIP commands. In each case, the specific device is read until end-of-file (ctl-Z for ASCII files, and a real end of file for non-ASCII disk files). Data from each device or file is concatenated from left to right until the last data source has been read. The destination device or file is written using the data from the source files, and an end-of-file character (ctl-Z) is appended to the result for ASCII files. Note that if the destination is a disk file, a temporary file is created (\$\$\$ secondary name) which is changed to the actual file name only upon successful completion of the copy. Files with the extension "COM" are always assumed to be non-ASCII.

The copy operation can be aborted at any time by depressing any key on the keyboard (a rubout suffices). PIP will respond with the message "ABORTED" to indicate that the operation was not completed. Note that if any operation is aborted, or if an error occurs during processing, PIP removes any pending commands which were set up while using the SUBMIT command.

It should also be noted that PIP performs a special function if the destination is a disk file with type "HEX" (an Intel hex formatted machine code file), and the source is an external peripheral device, such as a paper tape reader. In this case, the PIP program checks to ensure that the source file contains a properly formed hex file, with legal hexadecimal values and checksum records. When an invalid input record is found, PIP reports an error message at the console and waits for corrective action. It is usually sufficient to open the reader and rerun a section of the tape (pull the tape about 20 inches). When the tape is ready for the re-read, type a single carriage return at the console, and PIP will attempt another read. If the tape position cannot be properly read, simply continue the read (by typing a return following the error message), and enter the record manually with the ED program after the disk file is constructed. For convenience, PIP allows the end-of-file to be entered from the console if the source file is a RDR: device. In this case, the PIP program reads the device and monitors the keyboard. If ctl-Z is typed at the keyboard, then the read operation is terminated normally.

Valid PIP commands are shown below.

PIP LST: = X.PRN <cr>      Copy X.PRN to the LST device and terminate the PIP program.

PIP <cr>                      Start PIP for a sequence of commands (PIP prompts with "\*").

\*CON: = X.ASM,Y.ASM,Z.ASM <cr>

Concatenate three ASM files and copy to the CON device.

\*X.HEX = CON:,Y.HEX,PTR: <cr>

Create a HEX file by reading the CON (until a ctl-Z is typed), followed by data from Y.HEX, followed by data from PTR until a ctl-Z is encountered.

\*<cr>

Single carriage return stops PIP.

PIP PUN: = NUL:,X.ASM,EOF:,NUL: <cr>

Send 40 nulls to the punch device; then copy the X.ASM file to the punch, followed by an end-of-file (ctl-Z) and 40 more null characters.

The user can also specify one or more PIP parameters, enclosed in left and right square brackets, separated by zero or more blanks. Each parameter affects the copy operation, and the enclosed list of parameters must immediately follow the affected file or device. Generally, each parameter can be followed by an optional decimal integer value (the S and Q parameters are exceptions). The valid PIP parameters are listed below.

B      Block mode transfer: data is buffered by PIP until an ASCII x-off character (ctl-S) is received from the source device. This allows transfer of data to a disk file from a continuous reading device, such as a cassette reader. Upon receipt of the x-off, PIP clears the disk buffers and returns for more input data. The amount of data which can be buffered is dependent upon the memory size of the host system (PIP will issue an error message if the buffers overflow).

Dn     Delete characters which extend past column n in the transfer of data to the destination from the character source. This parameter is used most often to truncate long lines which are sent to a (narrow) printer or console device.

E      Echo all transfer operations to the console as they are being performed.

F      Filter form feeds from the file. All imbedded form feeds are removed. The P parameter can be used simultaneously to insert new form feeds.

Gn     Get file from user number n. (n is the range 0-15.) Allows one user area to receive data files from another. If the operator has issued the

USER 4 command at the CCP level, the PIP statement

PIP X.Y = X.Y[G2]

reads file X.Y from user number 2 into user area number 4. You cannot copy files into a different area than the one which is currently addressed by the USER command.

- H** Hex data transfer: all data is checked for proper Intel hex file format. Non-essential characters between hex records are removed during the copy operation. The console will be prompted for corrective action in case errors occur.
- I** Ignore “:00” records in the transfer of Intel hex format file (the I parameter automatically sets the H parameter).
- L** Translate upper case alphabets to lower case.
- N** Add line numbers to each line transferred to the destination, starting at one, and incrementing by 1. Leading zeroes are suppressed, and the number is followed by a colon. If N2 is specified, then leading zeroes are included, and a tab is inserted following the number. The tab is expanded if T is set.
- O** Object file (non-ASCII) transfer: the normal CP/M end of file is ignored.
- Pn** Include page ejects at every n lines (with an initial page eject). If n = 1 or is excluded altogether, page ejects occur every 60 lines. If the F parameter is used, form feed suppression takes place before the new page ejects are inserted.
- Qs†z** Quit copying from the source device or file when the string s (terminated by ctl-Z) is encountered.
- R** Read system files. Allows files with the system attribute to be included in PIP transfers. Otherwise, system files are not recognized.
- Ss†z** Start copying from the source device when the string s is encountered (terminated by ctl-Z). The S and Q parameters can be used to “abstract” a particular section of a file (such as a subroutine). The start and quit strings are always included in the copy operation.

**NOTE** — the strings following the s and q parameters are translated to upper case by the CCP if form (2) of the PIP command is used. Form (1) of the PIP invocation, however, does not perform the

automatic upper case translation.

(1) PIP <cr>

(2) PIP "command line" <cr>

- Tn** Expand tabs (ctl-I characters) to every nth column during the transfer of characters to the destination from the source.
- U** Translate lower case alphabets to upper case during the copy operation.
- V** Verify that data has been copied correctly by rereading after the write operation (the destination must be a disk file).
- W** Write over R/O files without console interrogation. Under normal operation, PIP will not automatically overwrite a file which is set to a permanent R/O status. It advises the user of the R/O status and waits for overwrite approval. W allows the user to bypass this interrogation process.
- Z** Zero the parity bit on input for each ASCII character.

The following are valid PIP commands which specify parameters in the file transfer:

PIP X.ASM = B:[v] <cr>      Copy X.ASM from drive B to the current drive and verify that the data was properly copied.

PIP LPT: = X.ASM[nt8u] <cr>      Copy X.ASM to the LPT: device; number each line, expand tabs to every eighth column, and translate lower case alphabets to upper case.

PIP PUN: = X.HEX[i],Y.ZOT[h] <cr>      First copy X.HEX to the PUN: device and ignore the trailing ":00" record in X.HEX; then continue the transfer of data by reading Y.ZOT, which contains hex records, including any ":00" records which it contains.

PIP X.LIB = Y.ASM [ sSUBR1:↑z qJMP L3↑z ] <cr>      Copy from the file Y.ASM into the file X.LIB. Start the copy when the string "SUBR1:" has been found, and quit copying after the string "JMP L3" is encountered.



PIP PRN: = X.ASM[p50]      Send X.ASM to the LST: device, with line numbers, tabs expanded to every eighth column, and page ejects at every 50th line. Note that nt8p60 is the assumed parameter list for a PRN file; p50 overrides the default value.

Note that the PIP program itself is initially copied to a user area (so that subsequent files can be copied) using the SAVE command. The sequence of operations shown below effectively moves PIP from one user area to the next.

|                   |                    |
|-------------------|--------------------|
| USER 0            | login user 0       |
| DDT PIP.COM       | load PIP in memory |
| (note PIP size s) |                    |
| G0                | return to CCP      |
| USER 3            | login user 3       |
| SAVE s PIP.com    |                    |

where *s* is the integral number of memory “pages” (256 byte segments) occupied by PIP. The number *s* can be determined when PIP.COM is located under DDT, by referring to the value under the “NEXT” display. If for example, the next available address is 1D00, then PIP.COM requires 1C hexadecimal pages (or 1 times 16 + 12 = 28 pages), and thus the value of *s* is 28 in the subsequent save. Once PIP is copied in this manner, it can then be copied to another disk belonging to the same user number through normal PIP transfers.

## ED

The ED program is the CP/M system context editor, which allows creation and alteration of ASCII files in the CP/M environment. Complete details of operation are given in Chapter 3 CP/M ED. In general, ED allows the operator to create and operate upon source files which are organized as a sequence of ASCII characters, separated by end-of-line characters (a carriage-return line-feed sequence). There is no practical restriction on line length (no single line can exceed the size of the working memory), which is instead defined by the number of characters typed between <cr>'s. The ED program has a number of commands for character string searching, replacement, and insertion, which are useful in the creation and correction of programs or text files under CP/M. Although the CP/M has a limited memory work space area (approximately 5000 characters in a 16K CP/M system), the file size which can be edited is not limited, since data is easily “paged” through this work area.

Upon initiation, ED creates the specified source file, if it does not exist, and opens the file for access. The programmer then “appends” data from the

source file into the work area, if the source file already exists (see the A command), for editing. The appended data can then be displayed, altered, and written from the work area back to the disk (see the W command). Particular points in the program can be automatically paged and located by context (see the N command), allowing easy access to particular portions of a large file.

Given that the operator has typed

ED X.ASM <cr>

the ED program creates an intermediate work file with the name

X.\$\$\$

to hold the edited data during the ED run. Upon completion of ED, the X.ASM file (original file) is renamed to X.BAK, and the edited work file is renamed to X.ASM. Thus, the X.BAK file contains the original (unedited) file, and the X.ASM file contains the newly edited file. The operator can always return to the previous version of a file by removing the most recent version, and renaming the previous version. Suppose, for example, that the current X.ASM file was improperly edited; the sequence of CCP commands shown below would reclaim the backup file.

DIR X.\*                      Check to see that BAK file is available.

ERA X.ASM                      Erase most recent version.

REN X.ASM=X.BAK      Rename the BAK file to ASM.

Note that the operator can abort the edit at any point (reboot, power failure, ctrl-C, or Q command) without destroying the original file. In this case, the BAK file is not created, and the original file is always intact.

The ED program also allows the user to “ping-pong” the source and create backup files between two disks. The form of the ED command in this case is

ED ufn d:

where ufn is the name of a file to edit on the currently logged disk and d is the name of an alternate drive. The ED program reads and processes the source file, and writes the new file to drive d, using the name ufn. Upon completion of processing, the original file becomes the backup file. Thus, if the operator is addressing disk A, the following command is valid:

## ED X.ASM B:

which edits the file X.ASM on drive A, creating the new file X.\$\$\$ on drive B. Upon completion of a successful edit, A:X.ASM is renamed to A:X.BAK, and B:X.\$\$\$ is renamed to B:X.ASM. For user convenience, the currently logged disk becomes drive B at the end of the edit. Note that if a file by the name B:X.ASM exists before the editing begins, the message

## FILE EXISTS

is printed at the console as a precaution against accidentally destroying a source file. In this case, the operator must first ERASE the existing file and then restart the edit operation.

Similar to other transient commands, editing can take place on a drive different from the currently logged disk by preceding the source file name by a drive name. Examples of valid edit requests are shown below

**ED A:X.ASM**                      Edit the file X.ASM on drive A, with new file and backup on drive A.

**ED B:X.ASM A:**                  Edit the file X.ASM on drive B to the temporary file X.\$\$\$ on drive A. On termination of editing, change X.ASM on drive B to X.BAK, and change X.\$\$\$ on drive A to X.ASM.

ED takes file attributes into account. If the operator attempts to edit a read/only file, the message

**\*\*FILE IS READ/ONLY\*\***

appears at the console. The file can be loaded and examined, but cannot be altered in any way. Normally the operator simply ends the edit session, and uses STAT to change the file attribute to R/W. If the edited file has the system attribute set, the message

**"SYSTEM" FILE NOT ACCESSIBLE**

is displayed at the console, and the edit session is aborted. Again, the STAT program can be used to change the system attribute if desired.

## SUBMIT

The SUBMIT command allows CP/M commands to be batched together for

automatic processing. The format of SUBMIT is: SUBMIT ufn  
parm #1...parm #n<cr>.

The ufn given in the SUBMIT command must be the filename of a file which exists on the currently logged disk, with an assumed file type of "SUB." The SUB file contains CP/M prototype commands, with possible parameter substitution. The actual parameters parm #1 ... parm #n are substituted into the prototype commands, and, if no errors occur, the file of substituted commands is processed sequentially by CP/M.

The prototype command file is created using the ED program, with interspersed "\$" parameters of the form

\$1 \$2 \$3 ... \$n

corresponding to the number of actual parameters which will be included when the file is submitted for execution. When the SUBMIT transient is executed, the actual parameters parm #1 ... parm #n are paired with the formal parameters \$1 ... \$n in the prototype commands. If the number of formal and actual parameters does not correspond, then the submit function is aborted with an error message at the console. The SUBMIT function creates a file of substituted commands with the name

\$\$\$SUB

on the logged disk. When the system reboots (at the termination of the SUBMIT), this command file is read by the CCP as a source of input, rather than the console. If the SUBMIT function is performed on any disk other than drive A, the commands are not processed until the disk is inserted into drive A and the system reboots. Further, the user can abort command processing at any time by typing a rubout when the command is read and echoed. In this case, the \$\$\$SUB file is removed, and the subsequent commands come from the console. Command processing is also aborted if the CCP detects an error in any of the commands. Programs which execute under CP/M can abort processing of command files when error conditions occur by simply erasing any existing \$\$\$SUB file.

In order to introduce dollar signs into a SUBMIT file, the user may type a "\$\$" which reduces to a single "\$" within the command file. Further, an up-arrow symbol "↑" may precede an alphabetic character x, which produces a single ctl-x character within the file.

The last command in a SUB file can initiate another SUB file, thus allowing chained batch commands.

Suppose the file ASMBL.SUB exists on disk and contains the prototype

commands

```
ASM $1
DIR $1.*
ERA *.BAK
PIP $2:=$1.PRN
ERA $1.PRN
```

and the command

```
SUBMIT ASMBL X PRN <cr>
```

is issued by the operator. The SUBMIT program reads the ASMBL.SUB file, substituting "X" for all occurrences of \$1 and "PRN" for all occurrences of \$2, resulting in a \$\$\$SUB file containing the commands

```
ASM X
DIR X.*
ERA *.BAK
PIP PRN:=X.PRN
ERA X.PRN
```

which are executed in sequence by the CCP.

The SUBMIT function can access a SUB file which is on an alternate drive by preceding the file name by a drive name. Submitted files are only acted upon, however, when they appear on drive A. Thus, it is possible to create a submitted file on drive B which is executed at a later time when it is inserted in drive A.

## **XSUB**

XSUB extends the power of the SUBMIT facility to include character input during program execution as well as entering command lines. The XSUB command is included as the first line of your submit file and, when executed, self-relocates directly below the CCP.

All subsequent submit command lines are processed by XSUB, so that programs which read buffered console input (BDOS function 10) receive their input directly from the submit file. For example, the file SAVER.SUB could contain the submit lines:

```
XSUB
DDT
I$1.HEX
R
G0
SAVE 1 $2.COM
```

with a subsequent SUBMIT command:

```
SUBMIT SAVER X Y
```

which substitutes X for \$1 and Y for \$2 in the command stream. The XSUB program loads, followed by DDT which is sent the command lines "IX.HEX" "R" and "G0", thus returning to the CCP. The final command "SAVE 1 Y.COM" is processed by the CCP.

The XSUB program remains in memory, and prints the message

```
(xsub active)
```

on each warm start operation to indicate its presence. Subsequent submit command streams do not require the XSUB, unless an intervening cold start has occurred. Note that XSUB must be loaded after DESPOOL, if both are to run simultaneously.

## DUMP

The DUMP program types the contents of the disk file (ufn) at the console in hexadecimal form. The file contents are listed sixteen bytes at a time, with the absolute byte address listed to the left of each line in hexadecimal. Long typeouts can be aborted by pushing the rubout key during printout. (The source listing of the DUMP program is given in the "CP/M Interface Guide" as an example of a program written for the CP/M environment.)

## BDOS Error Messages

There are three error situations which the Basic Disk Operating System intercepts during file processing. When one of these conditions is detected, the BDOS prints the message:

```
BDOS ERR ON x: error
```

where x is the drive name, and "error" is one of the three error messages:

```
BAD SECTOR
SELECT
R/O
```

The "BAD SECTOR" message indicates that the disk controller electronics has detected an error condition in reading or writing the diskette. This condition is generally due to a malfunctioning disk controller, or an extremely worn diskette. If you find that your system reports this error more than once a month, you should check the state of your controller electronics, and the condition of your media. You may also encounter this condition in reading files generated by a controller produced by a different manufacturer. Even though controllers are claimed to be IBM-compatible, one often finds small differences in recording formats. The MDS-800 controller, for example, requires two bytes of one's following the data CRC byte, which is not required in the IBM format. As a result, diskettes generated by the Intel MDS can be read by almost all other IBM-compatible systems, while disk files generated on other manufacturers' equipment will produce the "BAD SECTOR" message when read by the MDS. In any case, recovery from this condition is accomplished by typing a `ctl-C` to reboot (this is the safest!), or a return, which simply ignores the bad sector in the file operation. Note, however, that typing a return may destroy your diskette integrity if the operation is a directory write, so make sure you have adequate backups in this case.

The "SELECT" error occurs when there is an attempt to address a drive beyond the A through D range. In this case, the value of `x` in the error message gives the selected drive. The system reboots following any input from the console.

The R/O (read only) message occurs when there is an attempt to write to a diskette which has been designated as read-only in a `STAT` command, or has been set to read-only by the BDOS. In general, the operator should reboot CP/M either by using the warm start procedure `ctl-C` or by performing a cold start whenever the diskettes are changed. If a changed diskette is to be read but not written, BDOS allows the diskette to be changed without the warm or cold start, but internally marks the drive as read-only. The status of the drive is subsequently changed to read/write if a warm or cold start occurs. Upon issuing this message, CP/M waits for input from the console. An automatic warm start takes place following any input.





## **CHAPTER 2**

### **CP/M 2.0 INTERFACE GUIDE**

- **Introduction**
- **Operating System Call Conventions**
- **Sample File-to-File Copy Program**
- **Sample File Dump Utility**
- **Sample Random Access Program**
- **System Function Summary**



The transient program may use the CP/M I/O facilities to communicate with the operator's console and peripheral devices, including the disk subsystem. The I/O system is accessed by passing a "function number" and an "information address" to CP/M through the FDOS entry point at BOOT + 0005H. In the case of a disk read, for example, the transient program sends the number corresponding to a disk read, along with the address of an FCB to the CP/M FDOS. The FDOS, in turn, performs the operation and returns with either a disk read completion indication or an error number indicating that the disk read was unsuccessful. The function numbers and error indicators are given below.

## **Operating System Call Conventions**

The purpose of this section is to provide detailed information for performing direct operating system calls from user programs.

CP/M facilities which are available for access by transient programs fall into two general categories: simple device I/O, and disk file I/O. The simple device operations include:

- Read a Console Character
- Write a Console Character
- Read a Sequential Tape Character
- Write a Sequential Tape Character
- Write a List Device Character
- Get or Set I/O Status
- Print Console Buffer
- Read Console Buffer
- Interrogate Console Ready

The FDOS operations which perform disk Input/Output are

- Disk System Reset
- Drive Selection
- File Creation
- File Open
- File Close
- Directory Search
- File Delete
- File Rename
- Random or Sequential Read
- Random or Sequential Write
- Interrogate Available Disks
- Interrogate Selected Disk
- Set DMA Address
- Set/Reset File Indicators

As mentioned above, access to the FDOS functions is accomplished by passing a function number and information address through the primary entry point at location BOOT + 0005H. In general, the function number is passed in register C with the information address in the double byte pair DE. Single byte values are returned in register A, with double byte values returned in HL (a zero value is returned when the function number is out of range). For reasons of compatibility, register A = L and register B = H upon return in all cases. Note that the register passing conventions of CP/M agree with those of Intel's PL/M systems programming language. The list of CP/M function numbers is given below.

|                          |                          |
|--------------------------|--------------------------|
| 0 System Reset           | 19 Delete File           |
| 1 Console Input          | 20 Read Sequential       |
| 2 Console Output         | 21 Write Sequential      |
| 3 Reader Input           | 22 Make File             |
| 4 Punch Output           | 23 Rename File           |
| 5 List Output            | 24 Return Login Vector   |
| 6 Direct Console I/O     | 25 Return Current Disk   |
| 7 Get I/O Byte           | 26 Set DMA Address       |
| 8 Set I/O Byte           | 27 Get Addr (Alloc)      |
| 9 Print String           | 28 Write Protect Disk    |
| 10 Read Console Buffer   | 29 Get R/O Vector        |
| 11 Get Console Status    | 30 Set File Attributes   |
| 12 Return Version Number | 31 Get Addr (Disk Parms) |
| 13 Reset Disk System     | 32 Set/Get User Code     |
| 14 Select Disk           | 33 Read Random           |
| 15 Open File             | 34 Write Random          |
| 16 Close File            | 35 Compute File Size     |
| 17 Search for First      | 36 Set Random Record     |
| 18 Search for Next       |                          |

(Functions 28 and 32 should be avoided in application programs to maintain upward compatibility with MP/M.)

Upon entry to a transient program, the CCP leaves the stack pointer set to an eight level stack area with the CCP return address pushed onto the stack, leaving seven levels before overflow occurs. Although this stack is usually not used by a transient program (i.e., most transients return to the CCP through a jump to location 0000H), it is sufficiently large to make CP/M system calls since the FDOS switches to a local stack at system entry. The following assembly language program segment, for example, reads characters continuously until an asterisk is encountered, at which time control returns to the CCP (assuming a standard CP/M system with BOOT + 0000H):

|        |      |         |                          |
|--------|------|---------|--------------------------|
| BDOS   | EQU  | 0005H   | ;STANDARD CP/M ENTRY     |
| CONIN  | EQU  | 1       | ;CONSOLE INPUT FUNCTION  |
| ;      |      |         |                          |
| NEXTC: | ORG  | 0100H   | ;BASE OF TPA             |
|        | MVI  | C,CONIN | ;READ NEXT CHARACTER     |
|        | CALL | BDOS    | ;RETURN CHARACTER IN <A> |
|        | CPI  | **      | ;END OF PROCESSING?      |
|        | JNZ  | NEXTC   | ;LOOP IF NOT             |
|        | RET  |         | ;RETURN TO CCP           |
|        | END  |         |                          |

CP/M implements a named file structure on each disk, providing a logical organization which allows any particular file to contain any number of records from completely empty, to the full capacity of the drive. Each drive is logically distinct with a disk directory and file data area. The disk file names are in three parts: the drive select code, the file name consisting of one to eight non-blank characters, and the file type consisting of zero to three non-blank characters. The file type names the generic category of a particular file, while the file name distinguishes individual files in each category. The file types listed below name a few generic categories which have been established, although they are generally arbitrary:

|     |                   |        |                      |
|-----|-------------------|--------|----------------------|
| ASM | Assembler Source  | PLI    | PL/I Source File     |
| PRN | Printer Listing   | REL    | Relocatable Module   |
| HEX | Hex Machine Code  | TEX    | TEX Formatter Source |
| BAS | Basic Source File | BAK    | ED Source Backup     |
| INT | Intermediate Code | SYM    | SID Symbol File      |
| COM | CCP Command File  | \$\$\$ | Temporary File       |

Source files are treated as a sequence of ASCII characters, where each "line" of the source file is followed by a carriage-return line-feed sequence (0DH followed by 0AH). Thus one 128 byte CP/M record could contain several lines of source text. The end of an ASCII file is denoted by a control-Z character (1AH) or a real end of file, returned by the CP/M read operation. Control-Z characters embedded within machine code files (e.g., COM files) are ignored, however, and the end of file condition returned by CP/M is used to terminate read operations.

Files in CP/M can be thought of as a sequence of up to 65536 records of 128 bytes each, numbered from 0 through 65535, thus allowing a maximum of 8 megabytes per file. Note, however, that although the records may be considered logically contiguous, they may not be physically contiguous in the disk data area. Internally, all files are broken into 16K byte segments called logical extents, so that counters are easily maintained as 8-bit values. Although the decomposition into extents is discussed in the paragraphs which follow, they are of no particular consequence to the programmer since each extent is automatically accessed in both sequential and random access modes.

In the file operations starting with function number 15, DE usually addresses a file control block (FCB). Transient programs often use the default file control block area reserved by CP/M at location BOOT + 005CH (normally 005CH) for simple file operations. The basic unit of file information is a 128 byte record used for all file operations, thus a default location for disk I/O is provided by CP/M at location BOOT + 0080H (normally 0080H) which is the initial default DMA address (see function 26). All directory operations take place in a reserved area which does not affect write buffers as was the case in release 1, with the exception of Search First and Search Next, where compatibility is required.

The File Control Block (FCB) data area consists of a sequence of 33 bytes for sequential access and a series of 36 bytes in the case that the file is accessed randomly. The default file control block normally located at 005CH can be used for random access files, since the three bytes starting at BOOT + 007DH are available for this purpose. The FCB format is shown with the following fields:

|    |    |    |     |    |    |    |    |    |    |    |    |    |     |    |    |    |    |    |    |    |
|----|----|----|-----|----|----|----|----|----|----|----|----|----|-----|----|----|----|----|----|----|----|
| dr | f1 | f2 | /   | /  | f8 | t1 | t2 | t3 | ex | s1 | s2 | rc | d0  | /  | /  | dn | cr | r0 | r1 | r2 |
| 00 | 01 | 02 | ... | 08 | 09 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | ... | 31 | 32 | 33 | 34 | 35 |    |    |

where

- dr            drive code (0 - 16)  
              0 => use default drive for file  
              1 => auto disk select drive A,  
              2 => auto disk select drive B,  
              ...  
              16 => auto disk select drive P.
- f1 . . f8    contain the file name in ASCII upper case, with high bit = 0
- t1,t2,t3    contain the file type in ASCII upper case, with high bit = 0  
              t1', t2', and t3' denote the bit of these positions,  
              t1' = 1 => Read/Only file,  
              t2' = 1 => SYS file, no DIR list
- ex           contains the current extent number, normally set to 00 by the  
              user, but in range 0 - 31 during file I/O
- s1           reserved for internal system use
- s2           reserved for internal system use, set to zero on call to OPEN,  
              MAKE, SEARCH
- rc           record count for extent "ex," takes on values from 0 - 128

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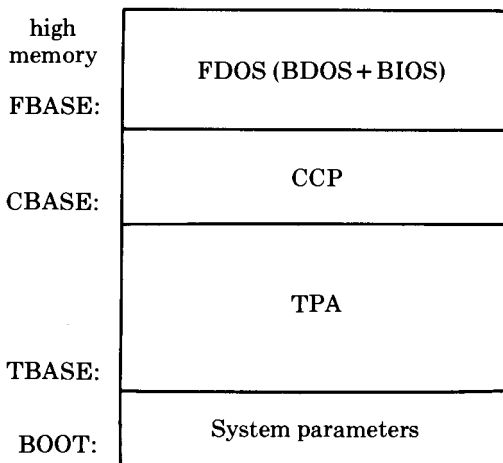




# Introduction

This manual describes CP/M, release 2, system organization including the structure of memory and system entry points. The intention is to provide the necessary information required to write programs which operate under CP/M, and which use the peripheral and disk I/O facilities of the system.

CP/M is logically divided into four parts, called the Basic I/O System (BIOS), the Basic Disk Operating System (BDOS), the Console command processor (CCP), and the Transient Program Area (TPA). The BIOS is a hardware-dependent module which defines the exact low level interface to a particular computer system which is necessary for peripheral device I/O. The BIOS and BDOS are logically combined into a single module with a common entry point, and referred to as the FDOS. The CCP is a distinct program which uses the FDOS to provide a human-oriented interface to the information which is cataloged on the backup storage device. The TPA is an area of memory (i.e., the portion which is not used by the FDOS and CCP) where various non-resistant operating system commands and user programs are executed. The lower portion of memory is reserved for system information and is detailed in later sections. Memory organization of the CP/M system is shown below:



Base addresses for the two Apple memory configurations that can be used with CP/M are shown in the table below:

| Module | 44K   | 56K (Language Card) |
|--------|-------|---------------------|
| CCP    | 9400H | C400H               |
| BDOS   | 9C00H | CC00H               |

BIOS  
Top of RAM

AA00H  
AFFFH

DA00H  
DFFFH

All standard CP/M versions assume  $BOOT = 0000H$ , which is the base of random access memory. The machine code found at location  $BOOT$  performs a system "warm start" which loads and initializes the programs and variables necessary to return control to the CCP. Thus, transient programs need only jump to location  $BOOT$  to return control to CP/M at the command level. Further, the standard versions assume  $TBASE = BOOT + 0100H$  which is normally location  $0100H$ . The principal entry point to the FDOS is at location  $BOOT + 0005H$  (normally  $0005H$ ) where a jump to  $FBASE$  is found. The address field at  $BOOT + 0006H$  (normally  $0006H$ ) contains the value of  $FBASE$  and can be used to determine the size of available memory, assuming the CCP is being overlaid by a transient program.

Transient programs are loaded into the TPA and executed as follows. The operator communicates with the CCP by typing command lines following each prompt. Each command line takes one of the forms:

```
command  
command file1  
command file1 file2
```

where "command" is either a built-in function such as `DIR` or `TYPE`, or the name of a transient command or program. If the command is a built-in function of CP/M, it is executed immediately. Otherwise, the CCP searches the currently addressed disk for a file by the name

`command.COM`

If the file is found, it is assumed to be a memory image of a program which executes in the TPA, and thus implicitly originates at  $TBASE$  in memory. The CCP loads the `COM` file from the disk into memory starting at  $TBASE$  and possibly extending up to  $CBASE$ .

If the command is followed by one or two file specifications, the CCP prepares one or two file control block (FCB) names in the system parameter area. These optional FCB's are in the form necessary to access files through the FDOS, and are described in the next section.

The transient program receives control from the CCP and begins execution, perhaps using the I/O facilities of the FDOS. The transient program is "called" from the CCP, and thus can simply return to the CCP upon completion of its processing, or can jump to  $BOOT$  to pass control back to CP/M. In the first case, the transient program must not use memory above  $CBASE$ , while in the latter case, memory up through  $FBASE-1$  is free.

The transient program may use the CP/M I/O facilities to communicate with the operator's console and peripheral devices, including the disk subsystem. The I/O system is accessed by passing a "function number" and an "information address" to CP/M through the FDOS entry point at BOOT + 0005H. In the case of a disk read, for example, the transient program sends the number corresponding to a disk read, along with the address of an FCB to the CP/M FDOS. The FDOS, in turn, performs the operation and returns with either a disk read completion indication or an error number indicating that the disk read was unsuccessful. The function numbers and error indicators are given below.

## **Operating System Call Conventions**

The purpose of this section is to provide detailed information for performing direct operating system calls from user programs.

CP/M facilities which are available for access by transient programs fall into two general categories: simple device I/O, and disk file I/O. The simple device operations include:

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- Write a Console Character
- Read a Sequential Tape Character
- Write a Sequential Tape Character
- Write a List Device Character
- Get or Set I/O Status
- Print Console Buffer
- Read Console Buffer
- Interrogate Console Ready

The FDOS operations which perform disk Input/Output are

- Disk System Reset
- Drive Selection
- File Creation
- File Open
- File Close
- Directory Search
- File Delete
- File Rename
- Random or Sequential Read
- Random or Sequential Write
- Interrogate Available Disks
- Interrogate Selected Disk
- Set DMA Address
- Set/Reset File Indicators

As mentioned above, access to the FDOS functions is accomplished by passing a function number and information address through the primary entry point at location BOOT + 0005H. In general, the function number is passed in register C with the information address in the double byte pair DE. Single byte values are returned in register A, with double byte values returned in HL (a zero value is returned when the function number is out of range). For reasons of compatibility, register A = L and register B = H upon return in all cases. Note that the register passing conventions of CP/M agree with those of Intel's PL/M systems programming language. The list of CP/M function numbers is given below.

|                          |                          |
|--------------------------|--------------------------|
| 0 System Reset           | 19 Delete File           |
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| 2 Console Output         | 21 Write Sequential      |
| 3 Reader Input           | 22 Make File             |
| 4 Punch Output           | 23 Rename File           |
| 5 List Output            | 24 Return Login Vector   |
| 6 Direct Console I/O     | 25 Return Current Disk   |
| 7 Get I/O Byte           | 26 Set DMA Address       |
| 8 Set I/O Byte           | 27 Get Addr (Alloc)      |
| 9 Print String           | 28 Write Protect Disk    |
| 10 Read Console Buffer   | 29 Get R/O Vector        |
| 11 Get Console Status    | 30 Set File Attributes   |
| 12 Return Version Number | 31 Get Addr (Disk Parms) |
| 13 Reset Disk System     | 32 Set/Get User Code     |
| 14 Select Disk           | 33 Read Random           |
| 15 Open File             | 34 Write Random          |
| 16 Close File            | 35 Compute File Size     |
| 17 Search for First      | 36 Set Random Record     |
| 18 Search for Next       |                          |

(Functions 28 and 32 should be avoided in application programs to maintain upward compatibility with MP/M.)

Upon entry to a transient program, the CCP leaves the stack pointer set to an eight level stack area with the CCP return address pushed onto the stack, leaving seven levels before overflow occurs. Although this stack is usually not used by a transient program (i.e., most transients return to the CCP through a jump to location 0000H), it is sufficiently large to make CP/M system calls since the FDOS switches to a local stack at system entry. The following assembly language program segment, for example, reads characters continuously until an asterisk is encountered, at which time control returns to the CCP (assuming a standard CP/M system with BOOT + 0000H):

|        |      |         |                          |
|--------|------|---------|--------------------------|
| BDOS   | EQU  | 0005H   | ;STANDARD CP/M ENTRY     |
| CONIN  | EQU  | 1       | ;CONSOLE INPUT FUNCTION  |
| ;      |      |         |                          |
| NEXTC: | ORG  | 0100H   | ;BASE OF TPA             |
|        | MVI  | C,CONIN | ;READ NEXT CHARACTER     |
|        | CALL | BDOS    | ;RETURN CHARACTER IN <A> |
|        | CPI  | **      | ;END OF PROCESSING?      |
|        | JNZ  | NEXTC   | ;LOOP IF NOT             |
|        | RET  |         | ;RETURN TO CCP           |
|        | END  |         |                          |

CP/M implements a named file structure on each disk, providing a logical organization which allows any particular file to contain any number of records from completely empty, to the full capacity of the drive. Each drive is logically distinct with a disk directory and file data area. The disk file names are in three parts: the drive select code, the file name consisting of one to eight non-blank characters, and the file type consisting of zero to three non-blank characters. The file type names the generic category of a particular file, while the file name distinguishes individual files in each category. The file types listed below name a few generic categories which have been established, although they are generally arbitrary:

|     |                   |        |                      |
|-----|-------------------|--------|----------------------|
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| PRN | Printer Listing   | REL    | Relocatable Module   |
| HEX | Hex Machine Code  | TEX    | TEX Formatter Source |
| BAS | Basic Source File | BAK    | ED Source Backup     |
| INT | Intermediate Code | SYM    | SID Symbol File      |
| COM | CCP Command File  | \$\$\$ | Temporary File       |

Source files are treated as a sequence of ASCII characters, where each "line" of the source file is followed by a carriage-return line-feed sequence (0DH followed by 0AH). Thus one 128 byte CP/M record could contain several lines of source text. The end of an ASCII file is denoted by a control-Z character (1AH) or a real end of file, returned by the CP/M read operation. Control-Z characters embedded within machine code files (e.g., COM files) are ignored, however, and the end of file condition returned by CP/M is used to terminate read operations.

Files in CP/M can be thought of as a sequence of up to 65536 records of 128 bytes each, numbered from 0 through 65535, thus allowing a maximum of 8 megabytes per file. Note, however, that although the records may be considered logically contiguous, they may not be physically contiguous in the disk data area. Internally, all files are broken into 16K byte segments called logical extents, so that counters are easily maintained as 8-bit values. Although the decomposition into extents is discussed in the paragraphs which follow, they are of no particular consequence to the programmer since each extent is automatically accessed in both sequential and random access modes.

In the file operations starting with function number 15, DE usually addresses a file control block (FCB). Transient programs often use the default file control block area reserved by CP/M at location BOOT + 005CH (normally 005CH) for simple file operations. The basic unit of file information is a 128 byte record used for all file operations, thus a default location for disk I/O is provided by CP/M at location BOOT + 0080H (normally 0080H) which is the initial default DMA address (see function 26). All directory operations take place in a reserved area which does not affect write buffers as was the case in release 1, with the exception of Search First and Search Next, where compatibility is required.

The File Control Block (FCB) data area consists of a sequence of 33 bytes for sequential access and a series of 36 bytes in the case that the file is accessed randomly. The default file control block normally located at 005CH can be used for random access files, since the three bytes starting at BOOT + 007DH are available for this purpose. The FCB format is shown with the following fields:

|    |    |    |     |    |    |    |    |    |    |    |    |    |     |    |    |    |    |    |    |    |
|----|----|----|-----|----|----|----|----|----|----|----|----|----|-----|----|----|----|----|----|----|----|
| dr | f1 | f2 | /   | /  | f8 | t1 | t2 | t3 | ex | s1 | s2 | rc | d0  | /  | /  | dn | cr | r0 | r1 | r2 |
| 00 | 01 | 02 | ... | 08 | 09 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | ... | 31 | 32 | 33 | 34 | 35 |    |    |

where

- dr            drive code (0 - 16)  
              0 => use default drive for file  
              1 => auto disk select drive A,  
              2 => auto disk select drive B,  
              ...  
              16 => auto disk select drive P.
- f1 .. f8      contain the file name in ASCII upper case, with high bit = 0
- t1,t2,t3      contain the file type in ASCII upper case, with high bit = 0  
              t1', t2', and t3' denote the bit of these positions,  
              t1' = 1 => Read/Only file,  
              t2' = 1 => SYS file, no DIR list
- ex            contains the current extent number, normally set to 00 by the  
              user, but in range 0 - 31 during file I/O
- s1            reserved for internal system use
- s2            reserved for internal system use, set to zero on call to OPEN,  
              MAKE, SEARCH
- rc            record count for extent "ex," takes on values from 0 - 128

|           |                                                                                                                                             |
|-----------|---------------------------------------------------------------------------------------------------------------------------------------------|
| d0 . . dn | filled-in by CP/M, reserved for system use                                                                                                  |
| cr        | current record to read or write in a sequential file operation, normally set to zero by user                                                |
| r0,r1,r2  | optional random record number in the range 0-65535, with overflow to r2, r0,r1 constitute a 16-bit value with low byte r0, and high byte r1 |

Each file being accessed through CP/M must have a corresponding FCB which provides the name and allocation information for all subsequent file operations. When accessing files, it is the programmer's responsibility to fill the lower sixteen bytes of the FCB and initialize the "cr" field. Normally, bytes 1 through 11 are set to the ASCII character values for the file name and file type, while all other fields are zero.

FCB's are stored in a directory area of the disk, and are brought into central memory before proceeding with file operations (see the OPEN and MAKE functions). The memory copy of the FCB is updated as file operations take place and later recorded permanently on disk at the termination of the file operation (see the CLOSE command).

The CCP constructs the first sixteen bytes of two optional FCB's for a transient by scanning the remainder of the line following the transient name, denoted by "file1" and "file2" in the prototype command line described above, with unspecified fields set to ASCII blanks. The first FCB is constructed at location BOOT + 005CH, and can be used as-is for subsequent file operations. The second FCB occupies the d0 . . . dn portion of the first FCB, and must be moved to another area of memory before use. If, for example, the operator types

PROGRAMME B:X.ZOT Y.ZAP

the file PROGRAMME.COM is loaded into the TPA, and the default FCB at BOOT + 005CH is initialized to drive code 2, file name "X" and file type "ZOT." The second drive code takes the default value 0, which is placed at BOOT + 006CH, with the file name "Y" placed into location BOOT + 006DH and file type "ZAP" located 8 bytes later at BOOT + 0075H. All remaining fields through "cr" are set to zero. Note again that it is the programmer's responsibility to move this second file name and type to another area, usually a separate file control block, before opening the file which begins at BOOT + 005CH, due to the fact that the open operation will overwrite the second name and type.

If no file names are specified in the original command, then the fields beginning at BOOT + 005DH and BOOT + 006DH contain blanks. In all

cases, the CCP translates lower case alphabets to upper case to be consistent with the CP/M file naming conventions.

As an added convenience, the default buffer area at location `BOOT + 0080H` is initialized to the command line tail typed by the operator following the program name. The first position contains the number of characters, with the characters themselves following the character count. Given the above command line, the area beginning at `BOOT + 0080H` is initialized as follows:

`BOOT + 0080H:`

|     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |
|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|
| +00 | +01 | +02 | +03 | +04 | +05 | +06 | +07 | +08 | +09 | +10 | +11 | +12 | +13 | +14 |     |
| 14  | "   | "   | "B" | "," | "X" | "," | "Z" | "O" | "T" | "   | "Y" | "," | "Z" | "A" | "P" |

where the characters are translated to upper case ASCII with uninitialized memory following the last valid character. Again, it is the responsibility of the programmer to extract the information from this buffer before any file operations are performed, unless the default DMA address is explicitly changed.

The individual functions are described in detail in the pages which follow.

## **FUNCTION 0: System Reset**

Entry Parameters:

Register C: 00H

The system reset function returns control to the CP/M operating system at the CCP level. The CCP re-initializes the disk subsystem by selecting and logging-in disk drive A. This function has exactly the same effect as a jump to location `BOOT`.

## **FUNCTION 1: CONSOLE INPUT**

Entry Parameters:

Register C: 01H

Returned Value :

Register A: ASCII Character

The console input function reads the next console character to register A. Graphic characters, along with carriage return, line feed, and backspace (ctl-H) are echoed to the console. Tab characters (ctl-I) are expanded in columns of eight characters. A check is made for start/stop scroll (ctl-S) and start/stop printer echo (ctl-P). The FDOS does not return to the calling program until a character has been typed, thus suspending execution of a character if not ready.



## **FUNCTION 2: CONSOLE OUTPUT**

### **Entry Parameters :**

Register C: 02H  
Register E: ASCII Character

The ASCII character from register E is sent to the console device. Similar to function 1, tabs are expanded and checks are made for start/stop scroll and printer echo.

## **FUNCTION 3: READER INPUT**

### **Entry Parameters :**

Register C: 03H

### **Returned Value :**

Register A: ASCII Character

The Reader Input function reads the next character from the logical reader into register A. Control does not return until the character has been read.

## **FUNCTION 4: PUNCH OUTPUT**

### **Entry Parameters :**

Register C: 04H  
Register E: ASCII Character

The Punch Output function sends the character from register E to the logical punch device.

## **FUNCTION 5: LIST OUTPUT**

### **Entry Parameters :**

Register C: 05H  
Register E: ASCII Character

The List Output function sends the ASCII character in register E to the logical listing device.

## **FUNCTION 6: DIRECT CONSOLE I/O**

### **Entry Parameters:**

Register C: 06H  
Register E: 0FFH (input) or  
char (output)

### **Returned Value :**

Register A: char or status  
(no value)

Direct console I/O is supported under CP/M for those specialized applications where unadorned console input and output is required. Use of this function should, in general, be avoided since it bypasses all of CP/M's normal control character functions (e.g., control-S and control-P). Programs which perform direct I/O through the BIOS under previous releases of CP/M, however, should be changed to use direct I/O under BDOS so that they can be fully supported under future releases of MP/M and CP/M.

Upon entry to function 6, register E either contains hexadecimal FF, denoting a console input request, or register E contains an ASCII character. If the input value is FF, then function 6 returns A = 00 if no character is ready, otherwise A contains the next console input character.

If the input value in E is not FF, then function 6 assumes that E contains a valid ASCII character which is sent to the console.

## **FUNCTION 7: GET I/O BYTE**

### **Entry Parameters:**

Register C: 07H

### **Returned Value:**

Register A: I/O Byte Value

The Get I/O Byte function returns the current value of IOBYTE in register A.

## **FUNCTION 8: SET I/O BYTE**

### **Entry Parameters:**

Register C: 08H  
Register E: I/O Byte Value

The Set I/O Byte function changes the system IOBYTE value to that given in register E.

## FUNCTION 9: PRINT STRING

Entry Parameters :

Register C: 09H

Registers DE: String Address

The Print String function sends the character string stored in memory at the location given by DE to the console device, until a "\$" is encountered in the string. Tabs are expanded as in function 2, and checks are made for start/stop scroll and printer echo.

## FUNCTION 10: READ CONSOLE BUFFER

Entry Parameters :

Register C: 0AH

Registers DE: Buffer Address

Returned Value :

Console Characters in Buffer

The Read Buffer function reads a line of edited console input into a buffer addressed by registers DE. Console input is terminated when either the input buffer overflows. The Read Buffer takes the form:

|        |    |    |    |    |    |    |    |    |     |    |
|--------|----|----|----|----|----|----|----|----|-----|----|
| DE: +0 | +1 | +2 | +3 | +4 | +5 | +6 | +7 | +8 | ... | +n |
| mx     | nc | c1 | c2 | c3 | c4 | c5 | c6 | c7 | ... | ?? |

where "mx" is the maximum number of characters which the buffer will hold (1 to 255), "nc" is the number of characters read (set by FDOS upon return), followed by the characters read from the console. If  $nc < mx$ , then uninitialized positions follow the last character, denoted by "??" in the above figure. A number of control functions are recognized during line editing:

|         |                                         |
|---------|-----------------------------------------|
| rub/del | removes the echoes the last character   |
| ctl-C   | reboots when at the beginning of line   |
| ctl-E   | causes physical end of line             |
| ctl-H   | backspaces one character position       |
| ctl-J   | (line feed) terminates input line       |
| ctl-M   | (return) terminates input line          |
| ctl-R   | retypes the current line after new line |
| ctl-X   | backspaces to beginning of current line |

Note also that certain functions which return the carriage to the leftmost

position (e.g., ctl-X) do so only to the column position where the prompt ended (in earlier releases, the carriage returned to the extreme left margin). This convention makes operator data input and line correction more legible.

## **FUNCTION 11: GET CONSOLE STATUS**

Entry Parameters :

Register C: 0BH

Return Value :

Register A: Console Status

The Console Status function checks to see if a character has been typed at the console. If a character is ready, the value 0FFH is returned in register A. Otherwise a 00H value is returned.

## **FUNCTION 12: RETURN VERSION NUMBER**

Entry Parameters :

Register C: 0CH

Returned Value :

Registers HL: Version Number

Function 12 provides information which allows version independent programming. A two-byte value is returned, with H=00 designating the CP/M release (H=01 for MP/M), and L=00 for all releases previous to 2.0. CP/M 2.0 returns a hexadecimal 20 in register L, with subsequent version 2 releases in the hexadecimal range 21, 22, through 2F. Using function 12, for example, you can write application programs which provide both sequential and random access functions, with random access disabled when operating under early releases of CP/M.

## **FUNCTION 13: RESET DISK SYSTEM**

Entry Parameters :

Register C: 0DH

The Reset Disk Function is used to programmatically restore the file system to a reset state where all disks are set to read/write (see functions 28 and 29), only disk drive A is selected, and the default DMA address is reset to BOOT + 0080H. This function can be used, for example, by an application program which requires a disk change without a system reboot.

## FUNCTION 14: SELECT DISK

### Entry Parameters :

Register C: 0EH  
Register E: Selected Disk

The Select Disk function designates the disk drive named in register E as the default disk for subsequent file operations, with E = 0 for drive A, 1 for drive B, and so-forth through 15 corresponding to drive P in a full sixteen drive system. The drive is placed in an "on-line" status which, in particular, activates its directory until the next cold start, warm start, or disk system reset operation. If the disk media is changed while it is on-line, the drive automatically goes to a read/only status in a standard CP/M environment (see function 28). FCB's which specify drive code zero (dr = 00H) automatically reference the currently selected default drive. Drive code values between 1 and 16, however, ignore the selected default drive and directly reference drives A through P.

## FUNCTION 15: OPEN FILE

### Entry Parameters :

Register C: 0FH  
Registers DE: FCB Address

### Returned Value :

Register A: Directory Code

The Open File operation is used to activate a file which currently exists in the disk directory for the currently active user number. The FDOS scans the referenced disk directory for a match in positions 1 through 14 of the FCB referenced by DE (byte 1 is automatically zeroed), where an ASCII question mark (3FH) matches any directory character in any of these positions. Normally, no question marks are included and, further, bytes "ex" and "s2" of the FCB are zero.

If a directory element is matched, the relevant directory information is copied into bytes d0 through dn of the FCB, thus allowing access to the files through subsequent read and write operations. Note that an existing file must not be accessed until a successful open operation is completed. Upon return, the open function returns a "directory code" with the value 0 through 3 if the open was successful, or 0FFH (255 decimal) if the file cannot be found. If question marks occur in the FCB then the first matching FCB is activated. Note that the current record ("cr") must be zeroed by the program if the file is to be accessed sequentially from the first record.

## FUNCTION 16: CLOSE FILE

### Entry Parameters :

Register C: 10H

Registers DE: FCB Address

### Returned Value :

Register A: Directory Code

The Close File function performs the inverse of the open file function. Given that the FCB addressed by DE has been previously activated through an open or make function (see functions 15 and 22), the close function permanently records the new FCB in the referenced disk directory. The FCB matching process for the close is identical to the open function. The directory code returned for a successful close operation is 0, 1, 2, or 3, while a 0FFH (255 decimal) is returned if the file name cannot be found in the directory. A file need not be closed if only read operations have taken place. If write operations have occurred, however, the close operation is necessary to permanently record the new directory information.

## FUNCTION 17: SEARCH FOR FIRST

### Entry Parameters :

Register C: 11H

Registers DE: FCB Address

### Returned Value :

Register A: Directory Code

Search First scans the directory for a match with the file given by the FCB addressed by DE. The value 255 (hexadecimal FF) is returned if the file is not found, otherwise 0, 1, 2, or 3 is returned indicating the file is present. In the case that the file is found, the current DMA address is filled with the record containing the directory entry, and the relative starting position is  $A * 32$  (i.e., rotate the A register left 5 bits, or ADD A five times). Although not normally required for application programs, the directory information can be extracted from the buffer at this position.

An ASCII question mark (63 decimal, 3F hexadecimal) in any position from "fl" through "ex" matches the corresponding field of any directory entry on the default or auto-selected disk drive. If the "dr" field contains an ASCII question mark, then the auto disk selected function is disabled, the default disk is searched, with the search function returning any matched entry, allocated or free, belonging to any user number. This latter function is not normally used by application programs, but does allow complete flexibility to scan all current directory values. If the "dr" field is not a question mark, the "s2" byte is automatically zeroed.

## **FUNCTION 18: SEARCH FOR NEXT**

Entry Parameters :

Register C: 12H

Returned Value :

Register A: Directory Code

The Search Next function is similar to the Search First function, except that the directory scan continues from the last matched entry. Similar to function 17, function 18 returns the decimal value 255 in A when no more directory items match.

## **FUNCTION 19: DELETE FILE**

Entry Parameters :

Register C: 13H

Registers DE: FCB Address

Returned Value :

Register A: Directory Code

The Delete File function removes files which match the FCB addresses by DE. The filename and type may contain ambiguous references (i.e., question marks in various positions), but the drive select code cannot be ambiguous, as in the Search and Search Next functions.

Function 19 returns a decimal 255 if the referenced file or files cannot be found, otherwise a value in the range 0 to 3 is returned.

## **FUNCTION 20: READ SEQUENTIAL**

Entry Parameters :

Register C: 14H

Registers DE: FCB Address

Returned Value :

Register A: Directory Code

Given that the FCB addressed by DE has been activated through an open or make function (numbers 15 and 22), the Read Sequential function reads the next 128 byte record from the file into memory at the current DMA address. The record is read from position "cr" of the extent, and the "cr" field is automatically incremented to the next record position. If the "cr" field overflows then the next logical extent is automatically opened and the "cr" field is reset to zero in preparation for the next read operation. The value 00H

is returned in the A register if the read operation was successful, while a non-zero value is returned if no data exists at the next record position (e.g., end of file occurs).

## **FUNCTION 21: WRITE SEQUENTIAL**

### **Entry Parameters :**

Register C: 15H  
Registers DE: FCB Address

### **Returned Value :**

Register A: Directory Code

Given that the FCB addressed by DE has been activated through an open or make function (numbers 15 and 22), the Write Sequential function writes the 128 byte data record at the current DMA address to the file named by the FCB. The record is placed at position "cr" of the file, and the "cr" field is automatically incremented to the next record position. If the "cr" field overflows then the next logical extent is automatically opened and the "cr" field is reset to zero in preparation for the next write operation. Write operations can take place into an existing file, in which case newly written records overlay those which already exist in the file. Register A = 00H upon return from a successful write operation, while a non-zero value indicates an unsuccessful write due to a full disk.

## **FUNCTION 22: MAKE FILE**

### **Entry Parameters :**

Register C: 16H  
Registers DE: FCB Address

### **Returned Value :**

Register A: Directory Code

The Make File operation is similar to the open file operation except that the FCB must name a file which does not exist in the currently referenced disk directory (i.e., the one named explicitly by a non-zero "dr" code, or the default disk if "dr" is zero). The FDOS creates the file and initializes both the directory and main memory value to an empty file. The programmer must ensure that no duplicate file names occur, and a preceding delete operation is sufficient if there is any possibility of duplication. Upon return, register A = 0, 1, 2, or 3 if the operation was successful and 0FFH (255 decimal) if no more directory space is available. The make function has the side-effect of activating the FCB and thus a subsequent open is not necessary.



## **FUNCTION 23: RENAME FILE**

### **Entry Parameters :**

Register C: 17H  
Registers DE: FCB Address

### **Returned Value :**

Register A: Directory Code

The Rename function uses the FCB addressed by DE to change all occurrences of the file named in the first 16 bytes to the file named in the second 16 bytes. The drive code "dr" at position 0 is used to select the drive, while the drive code for the new file name at position 16 of the FCB is assumed to be zero. Upon return, register A is set to a value between 0 and 3 if the rename was successful, and 0FFH (255 decimal) if the first file name could not be found in the directory scan.

## **FUNCTION 24: RETURN LOGIN VECTOR**

### **Entry Parameters :**

Register C: 18H

### **Returned Value :**

Registers HL: Login Vector

The login vector value returned by CP/M is a 16-bit value in HL, where the least significant bit of L corresponds to the first drive A, and the high order bit of H corresponds to the sixteenth drive, labelled P. A "0" bit indicates that the drive is not on-line, while a "1" bit marks a drive that is actively on-line due to an explicit disk drive selection, or an implicit drive select caused by a file operation which specified a non-zero "dr" field. Note that compatibility is maintained with earlier releases, since registers A and L contain the same values upon return.

## **FUNCTION 25: RETURN CURRENT DISK**

### **Entry Parameters :**

Register C: 19H

### **Returned Value :**

Register A: Current Disk

Function 25 returns the currently selected default disk number in register A. The disk numbers range from 0 through 15 corresponding to drives A through P.

## **FUNCTION 26: SET DMA ADDRESS**

### **Entry Parameters:**

Regular C: 1AH

Registers DE: DMA Address

“DMA” is an acronym for Direct Memory Address, which is often used in connection with disk controllers which directly access the memory of the mainframe computer to transfer data to and from the disk subsystem. Although many computer systems use non-DMA access (i.e., the data is transferred through programmed I/O operations), the DMA address has, in CP/M, come to mean the address at which the 128 byte data record resides before a disk write and after a disk read. Upon cold start, warm start, or disk system reset, the DMA address is automatically set to `BOOT + 0080H`. The Set DMA function, however, can be used to change this default value to address another area of memory where the data records reside. Thus, the DMA address becomes the value specified by DE until it is changed by a subsequent Set DMA function, cold start, warm start, or disk system reset.

## **FUNCTION 27: GET ADDR (ALLOC)**

### **Entry Parameters:**

Register C: 1BH

### **Returned Value :**

Registers HL: ALLOC Address

An “allocation vector” is maintained in main memory for each on-line disk drive. Various system programs use the information provided by the allocation vector to determine the amount of remaining storage (see the STAT program). Function 27 returns the base address of the allocation vector for the currently selected disk drive. The allocation information may, however, be invalid if the selected disk has been marked read/only. Although this function is not normally used by application programs, additional details of the allocation vector are found in the “CP/M Alteration Guide.”

## **FUNCTION 28: WRITE PROTECT DISK**

### **Entry Parameters:**

Register C: 1CH

The disk write protect function provides temporary write protection for the currently selected disk. Any attempt to write to the disk, before the next cold or warm start operation produces the message

Bdos Err on d: R/O

## **FUNCTION 29: GET READ/ONLY VECTOR**

Entry Parameters :

Register C: 1DH

Returned Value :

Registers HL: R/O Vector Value

Function 29 returns a bit vector in register pair HL which indicates drives which have the temporary read/only bit set. Similar to function 24, the least significant bit corresponds to drive A, while the most significant bit corresponds to drive P. The R/O bit is set either by the explicit call to function 28, or by the automatic software mechanisms within CP/M which detect changed disks.

## **FUNCTION 30: SET FILE ATTRIBUTES**

Entry Parameters :

Register C: 1EH

Registers DE: FCB Address

Returned Value :

Register A: Directory Code

The Set File Attributes function allows programmatic manipulation of permanent indicators attached to files. In particular, the R/O and System attributes (t1' and t2') can be set or reset. The DE pair addresses an unambiguous file name with the appropriate attributes set or reset. Function 30 searches for a match, and changes the matched directory entry to contain the selected indicators. Indicators f1' through f4' are not presently used, but may be useful for applications programs, since they are not involved in the matching process during file open and close operations. Indicators f5' through f8' and t3' are reserved for future system expansion.

## **FUNCTION 31: GET ADDR (DISK PARMS)**

Entry Parameters :

Register C: 1FH

Returned Value :

Registers HL: DPB Address

The address of the BIOS resident disk parameter block is returned in HL as a result of this function call. This address can be used for either of two purposes. First, the disk parameter values can be extracted for display and

space computation purposes, or transient programs can dynamically change the values of current disk parameters when the disk environment changes, if required. Normally, application programs will not require this facility.

## **FUNCTION 32: SET/GET USER CODE**

### **Entry Parameters :**

Register C: 20H  
Register E: 0FFH (get or  
User Code (set))

### **Returned Value :**

Register A: Current Code or  
(no value)

An application program can change or interrogate the currently active user number by calling function 32. If register E = 0FFH, then the value of the current user number is returned in register A, where the value is in the range 0 to 31. If register E is not 0FFH, then the current user number is changed to the value of E (modulo 32).

## **FUNCTION 33: READ RANDOM**

### **Entry Parameters :**

Register C: 21H  
Registers DE: FCB Address

### **Returned Value :**

Register A: Return Code

The Read Random function is similar to the sequential file read operation of previous releases, except that the read operation takes place at a particular record number, selected by the 24-bit value constructed from the three byte field following the FCB (byte positions r0 at 33, r1 at 34, and r2 at 35). Note that the sequence of 24 bits is stored with least significant byte first (r0), middle byte next (r1), and high byte last (r2). CP/M does not reference byte r2, except in computing the size of a file (function 35). Byte r2 must be zero, however, since a non-zero value indicates overflow past the end of file.

Thus, the r0,r1 byte pair is treated as a double-byte, or "word" value, which contains the record to read. This value ranges from 0 to 65535, providing access to any particular record of the 8 megabyte file. In order to process a file using random access, the base extent (extent 0) must first be opened. Although the base extent may or may not contain any allocated data, this ensures that the file is properly recorded in the directory, and is visible in DIR requests. The selected record number is then stored into the random record field (r0,r1), and the BDOS is called to read the record. Upon return from the

call, register A either contains an error code, as listed below, or the value 00 indicating the operation was successful. In the latter case, the current DMA address contains the randomly accessed record. Note that contrary to the sequential read operation, the record number is not advanced. Thus, subsequent random read operations continue to read the same record.

Upon each random read operation, the logical extent and current record values are automatically set. Thus, the file can be sequentially read or written, starting from the current randomly accessed position. Note, however, that in this case, the last randomly read record will be re-read as you switch from random mode to sequential read, and the last record will be re-written as you switch to a sequential write operation. You can, of course, simply advance the random record position following each random read or write to obtain the effect of a sequential I/O operation.

Error codes returned in register A following a random read are listed below.

- 01 reading unwritten data
- 02 (not returning in random mode)
- 03 cannot close current extent
- 04 seek to unwritten extent
- 05 (not returned in read mode)
- 06 seek past physical end of disk

Error code 01 and 04 occur when a random read operation accesses a data block which has not been previously written, or an extent which has not been created, which are equivalent conditions. Error 3 does not normally occur under proper system operation, but can be cleared by simply re-reading, or re-opening extent zero as long as the disk is not physically write protected. Error code 06 occurs whenever byte r2 is non-zero under the current 2.0 release. Normally, non-zero return codes can be treated as missing data, with zero return codes indicating operation complete.

## **FUNCTION 34: WRITE RANDOM**

Entry Parameters :

Register C: 22H  
Registers DE: FCB Address

Returned Value :

Register A: Return Code

The Write Random operation is initiated similar to the Read Random call, except that data is written to the disk from the current DMA address. Further, if the disk extent or data block which is the target of the write has not yet been allocated, the allocation is performed before the write operation

continues. As in the Read Random operation, the random record number is not changed as a result of the write. The logical extent number and current record positions of the file control block are set to correspond to the random record which is being written. Again, sequential read or write operations can commence following a random write, with the notation that the currently addressed record is either read or rewritten again as the sequential operation begins. You can also simply advance the random record position following each write to get the effect of a sequential write operation. Note that in particular, reading or writing the last record of an extent in random mode does not cause an automatic extent switch as it does in sequential mode.

The error codes returned by a random write are identical to the random read operation with the addition of error code 05, which indicates that a new extent cannot be created due to directory overflow.

### **FUNCTION 35: COMPUTE FILE SIZE**

Entry Parameters :

Register C: 23H

Registers DE: FCB Address

Returned Value :

Random Record Field Set

When computing the size of a file, the DE register pair addresses an FCB in random mode format (bytes r0, r1, and r2 are present). The FCB contains an unambiguous file name which is used in the directory scan. Upon return, the random record bytes contain the "virtual" file size which is, in effect, the record address of the record following the end of the file. If, following a call to function 35, the high record byte r2 is 01, then the file contains the maximum record count 65536. Otherwise, bytes r0 and r1 constitute a 16-bit value (r0 is the least significant byte, as before) which is the file size.

Data can be appended to the end of an existing file by simply calling function 35 to set the random record position to the end of file, then performing a sequence of random writes starting at the preset record address

The virtual size of a file corresponds to the physical size when the file is written sequentially. If, instead, the file was created in random mode and "holes" exist in the allocation, then the file may in fact contain fewer records than the size indicates. If, for example, only the last record of an eight megabyte file is written in random mode (i.e., record number 65535), then the virtual size is 65536 records, although only one block of data is actually allocated.

## FUNCTION 36: SET RANDOM RECORD

### Entry Parameters:

Register C: 24H  
Registers DE: FCB Address

### Returned Value :

Random Record Field Set

The Set Random Record function causes the BDOS to automatically produce the random record position from a file which has been read or written sequentially to a particular point. The function can be useful in two ways.

First, it is often necessary to initially read and scan a sequential file to extract the position of various "key" fields. As each key is encountered, function 36 is called to compute the random record position for the data corresponding to this key. If the data unit size is 128 bytes, the resulting record position is placed into a table with the key for later retrieval. After scanning the entire file and tabularizing the keys and their record numbers, you can move instantly to a particular keyed record by performing a random read using the corresponding random record number which was saved earlier. The scheme is easily generated when variable record lengths are involved since the program need only store the buffer-relative byte position along with the key and record number in order to find the exact starting position of the keyed data at a later time.

A second use of function 36 occurs when switching from a sequential read or write over to random read or write. A file is sequentially accessed to a particular point in the file, function 36 is called which sets the record number, and subsequent random read and write operations continue from the selected point in the file.

## Sample File-to-File Copy Program

The program shown below provides a relatively simple example of file operations. The program source file is created as COPY.ASM using the CP/M ED program and then assembled using ASM or MAC, resulting in a "HEX" file. The LOAD program is then used to produce a COPY.COM file which executes directly under the CCP. The program begins by setting the stack pointer to a local area, and then proceeds to move the second name from the default area at 006CH to a 33-byte file control block called DFCB. The DFCB is then prepared for file operations by clearing the current record field. At this point, the source and destination FCB's are ready for processing since the SFCB at 005CH is properly set-up by the CCP upon entry to the COPY program. That is, the first name is placed into the default FCB, with

the proper fields zeroed, including the current record field at 007CH. The program continues by opening the source file, deleting any existing destination file, and then creating the destination file. If all this is successful, the program loops at the label COPY until each record has been read from the source file and placed into the destination file. Upon completion of the data transfer, the destination file is closed and the program returns to the CCP command level by jumping to BOOT.

```

;      sample file-to-file copy program
;
;      at the ccp level, the command
;
;      copy a:x.y b:u.v
;
;      copies the file named x.y from drive
;      a to a file named u.v on drive b.
;
0000 = boot      equ      0000h  ; system reboot
0005 = bdos      equ      0005h  ; bdos entry point
005c = fcbl      equ      005ch  ; first file name
005c = sfcbl     equ      005ch  ; source fcb
006c = fcb2      equ      006ch  ; second file name
0080 = dbuff     equ      0080h  ; default buffer
0100 = tpa       equ      0100h  ; beginning of tpa
;
0009 = printf    equ      9      ; print buffer func#
000f = openf     equ      15     ; open file func#
0010 = closef    equ      16     ; close file func#
0013 = deletef   equ      19     ; delete file func#
0014 = readf     equ      20     ; sequential read
0015 = writef    equ      21     ; sequential write
0016 = makef     equ      22     ; make file func#
;
0100          org      tpa      ; beginning of tpa
0100 311b02    lxi      sp,stack; local stack
;
;      move second file name to dfcb
0103 0e10      mvi      c,16     ; half an fcb
0105 116c00    lxi      d,fcb2    ; source of move
0108 21da01    lxi      h,dfcb    ; destination fcb
010b 1a        mfcbl: ldax      d      ; source fcb
010c 13        inx      d      ; ready next
010d 77        mov      m,a      ; dest fcb
010e 23        inx      h      ; ready next
010f 0d        dcr      c      ; count 16...0
0110 c20b01    jnz      mfcbl    ; loop 16 times
;
;      name has been moved, zero cr
0113 af        xra      a      ; a = 00h
0114 32fa01    sta      dfcbcr   ; current rec = 0
;
;      source and destination fcb's ready
;
0117 115c00    lxi      d,sfcb    ; source file
011a cd6901    call     open     ; error if 255
011d 118701    lxi      d,nofile; ready message
0120 3c        inr      a      ; 255 becomes 0
0121 cc6101    cz       finis    ; done if no file
;
;      source file open, prep destination
0124 11da01    lxi      d,dfcb    ; destination
0127 cd7301    call     delete   ; remove if present
;
012a 11da01    lxi      d,dfcb    ; destination
012d cd8201    call     make     ; create the file
0130 119601    lxi      d,nodir  ; ready message

```



```

0133 3c          intr      a      ; 255 becomes 0
0134 cc6101      cz        finis   ; done if no dir space
;
; source file open, dest file open
; copy until end of file on source
;
0137 115c00      copy:     lxi      d,sfcb ; source
013a cd7801      call      read   ; read next record
013d b7          ora       a      ; end of file?
013e c25101      jnz       eofile  ; skip write if so
;
; not end of file, write the record
0141 11da01      lxi      d,dfcb ; destination
0144 cd7d01      call      write  ; write record
0147 11a901      lxi      d,space ; ready message
014a b7          ora       a      ; 00 if write ok
014b c46101      cm       finis   ; end if so
014e c33701      jmp       copy   ; loop until eof
;
eofile: ; end of file, close destination
0151 11da01      lxi      d,dfcb ; destination
0154 cd6e01      call      close  ; 255 if error
0157 21bb01      lxi      h,wrprot; ready message
015a 3c          intr      a      ; 255 becomes 00
015b cc6101      cz        finis   ; shouldn't happen
;
; copy operation complete, end
015e 11cc01      lxi      d,normal; ready message
;
finis: ; write message given by de, reboot
0161 0e09      mvi      c,printf
0163 cd0500      call      bdos   ; write message
0166 c30000      jmp      boot    ; reboot system
;
; system interface subroutines
; (all return directly from bdos)
;
0169 0e0f      open:     mvi      c,openf
016b c30500      jmp      bdos
;
016e 0e10      close:    mvi      c,closef
0170 c30500      jmp      bdos
;
0173 0e13      delete:   mvi      c,deletf
0175 c30500      jmp      bdos
;
0178 0e14      read:     mvi      c,readf
017a c30500      jmp      bdos
;
017d 0e15      write:    mvi      c,writf
017f c30500      jmp      bdos
;
0182 0e16      make:     mvi      c,makef
0184 c30500      jmp      bdos
;
; console messages
0187 6e6f20fnofile: db      'no source file$'
0196 6e6f209nodir:  db      'no directory space$'
01a9 6f7574ospace:  db      'out of data space$'
01bb 7772695wrprot: db      'write protected?$'
01cc 636f700normal: db      'copy complete$'
;
; data areas
01da          dfcb:      ds       33      ; destination fcb
01fa =        ofcbr      equ      dfcb+32 ; current record
;
01fb          os         32          ; 16 level stack
021b          stack:     end

```

Note that there are several simplifications in this particular program. First, there are no checks for invalid file names which could, for example, contain ambiguous references. This situation could be detected by scanning the 32 byte default area starting at location 005CH for ASCII question marks. A check should also be made to ensure that the file names have, in fact, been included (check locations 005DH and 006DH for non-blank ASCII characters). Finally, a check should be made to ensure that the source and destination file names are different. A speed improvement could be made by buffering more data on each read operation. One could, for example, determine the size of memory by fetching FBASE from location 0006H and use the entire remaining portion of memory for a data buffer. In this case, the programmer simply resets the DMA address to the next successive 128 byte area before each read. Upon writing to the destination file, the DMA address is reset to the beginning of the buffer and incremented by 128 bytes to the end as each record is transferred to the destination file.

## Sample File Dump Utility.

The file dump program shown below is slightly more complex than the single copy program given in the previous section. The dump program reads an input file, specified in the CCP command line, and displays the content of each record in hexadecimal format at the console. Note that the dump program saves the CCP's stack upon entry, resets the stack to a local area, and restores the CCP's stack before returning directly to the CCP. Thus, the dump program does not perform warm start at the end of processing.

```

; DUMP program reads input file and displays hex data
;
0100      org      100h
0005 =    bdos     equ      0005h    ;dos entry point
0001 =    cons     equ      1        ;read console
0002 =    typef     equ      2        ;type function
0009 =    printf    equ      9        ;buffer print entry
000b =    brkf     equ      11       ;break key function (true if char
000f =    openf     equ      15       ;file open
0014 =    readf     equ      20       ;read function

;
005c =    fcb       equ      5ch      ;file control block address
0080 =    buff      equ      80h      ;input disk buffer address

;
; non graphic characters
000d =    cr        equ      0dh      ;carriage return
000a =    lf        equ      0ah      ;line feed

;
; file control block definitions
005c =    fcbdn     equ      fcb+0    ;disk name
005d =    fcbfn     equ      fcb+1    ;file name
0065 =    fcbft     equ      fcb+9    ;disk file type (3 characters)
0068 =    fcbrl     equ      fcb+12   ;file's current reel number
006b =    fcbrc     equ      fcb+15   ;file's record count (0 to 128)
007c =    fcbcr     equ      fcb+32   ;current (next) record number (0
007d =    fcbln     equ      fcb+33   ;fcb length

;
; set up stack
0100 210000    lxi      h,0
0103 39        dad      sp

; entry stack pointer in hl from the ccp

```

```

0104 221502      shld      oldsp
                  set sp to local stack area (restored at finis)
0107 315702      lxi       sp,stktp
                  read and print successive buffers
010a cdc101      call      setup ;set up input file
010d feff        cpi       255 ;255 if file not present
010f c21b01      jnz       openok ;skip if open is ok
                  ;
                  ; file not there, give error message and return
0112 11f301      lxi       d,opnmsg
0115 cd9c01      call      err
0118 c35101      jmp       finis ;to return
                  ;
openok: ;open operation ok, set buffer index to end
011b 3e80        mvi       a,80h
011d 321302      sta       ibp ;set buffer pointer to 80h
                  ; hl contains next address to print
0120 210000      lxi       h,0 ;start with 0000
                  ;
gloop:
0123 e5          push      h ;save line position
0124 cda201      call      gnb
0127 e1          pop       h ;recall line position
0128 da5101      jc        finis ;carry set by gnb if end file
012b 47          mov       b,a
                  ; print hex values
                  ; check for line fold
012c 7d          mov       a,l
012d e60f        ani       0fh ;check low 4 bits
012f c24401      jnz       nonum
                  ; print line number
0132 cd7201      call      crlf
                  ;
                  ; check for break key
0135 cd5901      call      break
                  ; accum lsb = 1 if character ready
0138 0f          rrc        ;into carry
0139 da5101      jc        finis ;don't print any more
                  ;
013c 7c          mov       a,h
013d cd8f01      call      phex
0140 7d          mov       a,l
0141 cd8f01      call      phex
nonum:
0144 23          inx        h ;to next line number
0145 3e20        mvi       a,' '
0147 cd6501      call      pchar
014a 78          mov       a,b
014b cd8f01      call      phex
014e c32301      jmp       gloop
                  ;
finis:
                  ; end of dump, return to ccp
                  ; (note that a jmp to 0000h reboots)
0151 cd7201      call      crlf
0154 2a1502      lhld      oldsp
0157 f9          sphl
                  ; stack pointer contains ccp's stack location
0158 c9          ret        ;to the ccp
                  ;
                  ;
                  ; subroutines
                  ;
break: ;check break key (actually any key will do)
0159 e5d5c5      push h! push d! push b; environment saved
015c 0e0b        mvi       c,brkf
015e cd0500      call      bdos
0161 c1d1e1      pop b! pop d! pop h; environment restored
0164 c9          ret
                  ;
pchar: ;print a character

```

```

0165 e5d5c5      push h! push d! push b; saved
0168 0e02        mvi      c,typef
016a 5f          mov       e,a
016b cd0500      call      bdos
016e c1d1e1      pop b! pop d! pop h; restored
0171 c9          ret

;
; crlf:
0172 3e0d        mvi      a,cr
0174 cd6501      call      pchar
0177 3e0a        mvi      a,lf
0179 cd6501      call      pchar
017c c9          ret

;
;
; pnib: ;print nibble in reg a
017d e60f        ani      0fh ;low 4 bits
017f fe0a        cpi      10
0181 d28901      jnc      pl0
; less than or equal to 9
0184 c630        adi      '0'
0186 c38b01      jmp      prn
;
; greater or equal to 10
0189 c637        pl0:     adi      'a' - 10
018b cd6501      prn:     call     pchar
018e c9          ret

;
; phex: ;print hex char in reg a
018f f5          push     psw
0190 0f          rrc
0191 0f          rrc
0192 0f          rrc
0193 0f          rrc
0194 cd7d01      call     pnib ;print nibble
0197 f1          pop      psw
0198 cd7d01      call     pnib
019b c9          ret

;
; err: ;print error message
; d,e addresses message ending with "$"
019c 0e09        mvi      c,printf ;print buffer function
019e cd0500      call      bdos
01a1 c9          ret

;
;
; gnb: ;get next byte
01a2 3a1302      lda      ibp
01a5 fe80        cpi      80h
01a7 c2b301      jnz      g0
; read another buffer
;
;
01aa cdce01      call     disk
01ad b7          ora      a ;zero value if read ok,
01ae cab301      jz       g0 ;for another byte
; end of data, return with carry set for eof
01b1 37          stc
01b2 c9          ret

;
; g0: ;read the byte at buff+reg a
01b3 5f          mov      e,a ;ls byte of buffer index
01b4 1600        mvi      d,0 ;double precision index to de
01b6 3c          inr      a ;index=index+1
01b7 321302      sta      ibp ;back to memory
; pointer is incremented
; save the current file address
01ba 218000      lxi      h,buff
01bd 19          dad      d
; absolute character address is in hl
01be 7e          mov      a,m

```

```

; byte is in the accumulator
01bf b7 ora a ;reset carry bit
01c0 c9 ret
;
; setup: ;set up file
; open the file for input
01c1 af xra a ;zero to accum
01c2 327c00 sta fcbcr ;clear current record
;
01c5 115c00 lxi d, fcb
01c8 0e0f mvi c, openf
01ca cd0500 call bdos
; 255 in accum if open error
01cd c9 ret
;
; disk: ;read disk file record
01ce e5d5c5 push h! push d! push b
01d1 115c00 lxi d, fcb
01d4 0e14 mvi c, readf
01d6 cd0500 call bdos
01d9 c1d1e1 pop b! pop d! pop h
01dc c9 ret
;
; fixed message area
01dd 46494c0signon: db 'file du p version 2.0$'
01f3 0d0a4e0opnmsg: db cr, lf, 'no input file present on disk$'
;
; variable area
0213 ibp: ds 2 ;input buffer pointer
0215 oldsp: ds 2 ;entry sp value from ccp
;
; stack area
0217 ds 64 ;reserve 32 level stack
; stktop:
;
0257 ; end

```

## Sample Random Access Program.

This manual is concluded with a rather extensive, but complete example of random access operation. The program listed below performs the simple function of reading or writing random records upon command from the terminal. Given that the program has been created, assembled, and placed into a file labelled RANDOM.COM, the CCP level command:

RANDOM X.DAT

starts the test program. The program looks for a file by the name X.DAT (in this particular case) and, if found, proceeds to prompt the console for input. If not found, the file is created before the prompt is given. Each prompt takes the form

next command?

and is followed by operator input, terminated by a carriage return. The input commands take the form

nW nR Q

where n is an integer value in the range 0 to 65535, and W, R, and Q are simple command characters corresponding to random write, random read, and quit processing, respectively. If the W command is issued, the RANDOM program issues the prompt

type data:

The operator then responds by typing up to 127 characters, followed by a carriage return. RANDOM then writes the character string into the X.DAT file at record n. If the R command is issued, RANDOM reads record number n and displays the string value at the console. If the Q command is issued, the X.DAT file is closed, and the program returns to the console command processor. In the interest of brevity, the only error message is

error, try again

The program begins with an initialization section where the input file is opened or created, followed by a continuous loop at the label "ready" where the individual commands are interpreted. The default file control block at 005CH and the default buffer at 0080H are used in all disk operations. The utility subroutines then follow, which contain the principal input line processor, called "readc." This particular program shows the elements of random access processing, and can be used as the basis for further program development.

```

;*****
;*
;* sample random access program for cp/m 2.0
;*
;*****
0100      org.      100h      ;base of tpa
;
0000 =    reboot   equ      0000h ;system reboot
0005 =    bdos     equ      0005h ;bdos entry point
;
0001 =    coninp   equ      1      ;console input function
0002 =    conout   equ      2      ;console output function
0009 =    pstring  equ      9      ;print string until '$'
000a =    rstring  equ      10     ;read console buffer
000c =    version  equ      12     ;return version number
000f =    openf    equ      15     ;file open function
0010 =    closef   equ      16     ;close function
0016 =    makef    equ      22     ;make file function
0021 =    readr    equ      33     ;read random
0022 =    writr    equ      34     ;write random
;
005c =    fcb      equ      005ch ;default file control block
007d =    ranrec   equ      fcb+33 ;random record position
007f =    ranovf   equ      fcb+35 ;high order (overflow) byte
0080 =    buff     equ      0080h ;buffer address
;
000d =    cr       equ      0dh    ;carriage return
000a =    lf       equ      0ah    ;line feed
;
;*****
;*
;* load SP, set-up file for random access
;*
;*****

```

```

0100 31bc0      lxi      sp,stack
;
;      version 2.0?
0103 0e0c      mvi      c,version
0105 cd050      call     bdos
0108 fe20      cpi      20h      ;version 2.0 or better?
010a d2160      jnc      versok
;      bad version, message and go back
010d 111b0      lxi      d,badver
0110 cdda0      call     print
0113 c3000      jmp      reboot
;
versok:
;      correct version for random access
0116 0e0f      mvi      c,openf ;open default fcb
0118 115c0      lxi      d,fcf
011b cd050      call     bdos
011e 3c        inr      a      ;err 255 becomes zero
011f c2370      jnz      ready
;
;      cannot open file, so create it
0122 0e16      mvi      c,makef
0124 115c0      lxi      d,fcf
0127 cd050      call     bdos
012a 3c        inr      a      ;err 255 becomes zero
012b c2370      jnz      ready
;
;      cannot create file, directory full
012e 113a0      lxi      d,noSPACE
0131 cdda0      call     print
0134 c3000      jmp      reboot ;back to ccp
;
;*****
; *
; * loop back to "ready" after each command
; *
; *
;*****
;
ready:
;      file is ready for processing
;
0137 cde50      call     readcom ;read next command
013a 227d0      shld     ranrec ;store input record#
013d 217f0      lxi      h,ranovf
0140 3600      mvi      m,0      ;clear high byte if set
0142 fe51      cpi      'Q'      ;quit?
0144 c2560      jnz      notq
;
;      quit processing, close file
0147 0e10      mvi      c,closef
0149 115c0      lxi      d,fcf
014c cd050      call     bdos
014f 3c        inr      a      ;err 255 becomes 0
0150 cab90      jz       error ;error message, retry
0153 c3000      jmp      reboot ;back to ccp
;
;*****
; *
; * end of quit command, process write
; *
; *
;*****
notq:
;      not the quit command, random write?
0156 fe57      cpi      'W'
0158 c2890      jnz      notw
;
;      this is a random write, fill buffer until cr
015b 114d0      lxi      d,datmsg
015e cdda0      call     print ;data prompt
0161 0e7f      mvi      c,127 ;up to 127 characters
0163 21800      lxi      h,buff ;destination

```

```

rloop: ;read next character to buff
0166 c5      push    b      ;save counter
0167 e5      push    h      ;next destination
0168 cdc20    call    getchr ;character to a
016b e1      pop     h      ;restore counter
016c c1      pop     b      ;restore next to fill
016d fe0d    cpi     cr     ;end of line?
016f ca780   jz      erloop
;          not end, store character
0172 77      mov     m,a
0173 23      inx     h      ;next to fill
0174 0d      dcr     c      ;counter goes down
0175 c2660   jnz     rloop  ;end of buffer?

erloop:
;          end of read loop, store 00
0178 3600    mvi     m,0
;
;          write the record to selected record number
017a 0e22    mvi     c,writer
017c 115c0   lxi     d,fcB
017f cd050   call    bdos
0182 b7      ora     a      ;error code zero?
0183 c2b90   jnz     error  ;message if not
0186 c3370   jmp     ready  ;for another record
;
;*****
;*
;* end of write command, process read
;*
;*****
notw:
;          not a write command, read record?
0189 fe52    cpi     'R'
018b c2b90   jnz     error  ;skip if not
;
;          read random record
018e 0e21    mvi     c,readr
0190 115c0   lxi     d,fcB
0193 cd050   call    bdos
0196 b7      ora     a      ;return code 00?
0197 c2b90   jnz     error
;
;          read was successful, write to console
019a cdcf0   call    crlf   ;new line
019d 0e80    mvi     c,128  ;max 128 characters
019f 21800   lxi     h,buff  ;next to get

wloop:
01a2 7e      mov     a,m     ;next character
01a3 23      inx     h     ;next to get
01a4 e67f    ani     7fh     ;mask parity
01a6 ca370   jz      ready  ;for another command if 00
01a9 c5      push    b     ;save counter
01aa e5      push    h     ;save next to get
01ab fe20    cpi     ' '    ;graphic?
01ad d4c80   cnc     putchr ;skip output if not
01b0 e1      pop     h
01b1 c1      pop     b
01b2 0d      dcr     c      ;count=count-1
01b3 c2a20   jnz     wloop
01b6 c3370   jmp     ready
;
;*****
;*
;* end of read command, all errors end-up here
;*
;*****
;
error:
01b9 11590   lxi     d,errmsg
01bc cdda0   call    print
01bf c3370   jmp     ready

```



```

;
;*****
;*
;* utility subroutines for console i/o
;*
;*****
getchr:
;read next console character to a
01c2 0e01 mvi c,coninp
01c4 cd050 call bdos
01c7 c9 ret

;
putchr:
;write character from a to console
01c8 0e02 mvi c,conout
01ca 5f mov e,a ;character to send
01cb cd050 call bdos ;send character
01ce c9 ret

;
crlf:
;send carriage return line feed
01cf 3e0d mvi a,cr ;carriage return
01d1 cdc80 call putchr
01d4 3e0a mvi a,lf ;line feed
01d6 cdc80 call putchr
01d9 c9 ret

;
print:
;print the buffer addressed by de until $
01da d5 push d
01db cdcf0 call crlf
01de d1 pop d ;new line
01df 0e09 mvi c,pstring
01e1 cd050 call bdos ;print the string
01e4 c9 ret

;
readcom:
;read the next command line to the conbuf
01e5 116b0 lxi d,prompt
01e8 cdda0 call print ;command?
01eb 0e0a mvi c,rstring
01ed 117a0 lxi d,conbuf
01f0 cd050 call bdos ;read command line
; command line is present, scan it
01f3 21000 lxi h,0 ;start with 0000
01f6 117c0 lxi d,conlin;command line
01f9 1a readc: ldax d ;next command character
01fa 13 inx d ;to next command position
01fb b7 ora a ;cannot be end of command
01fc c8 rz
; not zero, numeric?
01fd d630 sui '0'
01ff fe0a cpi 10 ;carry if numeric
0201 d2130 jnc endrd
; add-in next digit
0204 29 dad h ;*2
0205 4d mov c,l
0206 44 mov b,h ;bc = value * 2
0207 29 dad h ;*4
0208 29 dad h ;*8
0209 09 dad b ;*2 + *8 = *10
020a 85 add l ;+digit
020b 6f mov l,a
020c d2f90 jnc readc ;for another char
020f 24 inr h ;overflow
0210 c3f90 jmp readc ;for another char
endrd:
; end of read, restore value in a
0213 c630 adi '0' ;command
0215 fe61 cpi 'a' ;translate case?

```

```

0217 d8          rc
;              lower case, mask lower case bits
0218 e65f        ani      101$1111b
021a c9          ret

;*****
; *
; * string data area for console messages
; *
;*****
badver:
021b 536f79      db        'sorry, you need cp/m version 2$'
nospace:
023a 4e6f29      db        'no directory spaces$'
datmsg:
024d 547970      db        'type data: $'
errmsg:
0259 457272      db        'error, try again.$'
prompt:
026b 4e6570      db        'next command? $'
;*****
; *
; * fixed and variable data area
; *
;*****
027a 21          conbuf: db      conlen ;length of console buffer
027b             consiz: ds      1      ;resulting size after read
027c             conlin: ds      32     ;length 32 buffer
0201 =           conlen equ      $-consiz
;
029c             ds          32        ;16 level stack
stack:
02bc             end

```

Again, major improvements could be made to this particular program to enhance its operation. In fact, with some work, this program could evolve into a simple data base management system. One could, for example, assume a standard record size of 128 bytes, consisting of arbitrary fields within the record. A program, called GETKEY, could be developed which first reads a sequential file and extracts a specific field defined by the operator. For example, the command

GETKEY NAMES.DAT LASTNAME 10 20

would cause GETKEY to read the data base file NAMES.DAT and extract the "LASTNAME" field from each record, starting at position 10 and ending at character 20. GETKEY builds a table in memory consisting of each particular LASTNAME field, along with its 16-bit record number location within the file. The GETKEY program then sorts this list, and writes a new file, called LASTNAME.KEY, which is an alphabetical list of LASTNAME fields with their corresponding record numbers. (This list is called an "inverted index" in information retrieval parlance.)

Rename the program shown above as QUERY, and massage it a bit so that it reads a sorted key file into memory. The command line might appear as:

QUERY NAMES.DAT LASTNAME.KEY

Instead of reading a number, the QUERY program reads an alphanumeric string which is a particular key to find in the NAMES.DAT data base. Since the LASTNAME.KEY list is sorted, you can find a particular entry quite rapidly by performing a "binary search," similar to looking up a name in the telephone book. That is, starting at both ends of the list, you examine the entry halfway in between and, if not matched, split either the upper half or the lower half for the next search. You'll quickly reach the item you're looking for (in  $\log_2(n)$  steps) where you'll find the corresponding record number. Fetch and display this record at the console, just as we have done in the program shown above.

At this point you're just getting started. With a little more work, you can allow a fixed grouping size which differs from the 128 byte record shown above. This is accomplished by keeping track of the record number as well as the byte offset within the record. Knowing the group size, you randomly access the record containing the proper group, offset to the beginning of the group within the record read sequentially until the group size has been exhausted.

Finally, you can improve QUERY considerably by allowing boolean expressions which compute the set of records which satisfy several relationships, such as a LASTNAME between HARDY and LAUREL, and an AGE less than 45. Display all the records which fit this description. Finally, if your lists are getting too big to fit into memory, randomly access your key files from the disk as well. One note of consolation after all this work: if you make it through the project, you'll have no more need for this manual!

# System Function Summary

| FUNC | FUNCTION NAME         | INPUT<br>PARAMETERS | OUTPUT<br>RESULTS |
|------|-----------------------|---------------------|-------------------|
| 0    | System Reset          | none                | none              |
| 1    | Console Input         | none                | A = char          |
| 2    | Console Output        | E = char            | none              |
| 3    | Reader Input          | none                | A = char          |
| 4    | Punch Output          | E = char            | none              |
| 5    | List Output           | E = char            | none              |
| 6    | Direct Console I/O    | see def             | see def           |
| 7    | Get I/O Byte          | none                | A = IOBYTE        |
| 8    | Set I/O Byte          | E = IOBYTE          | none              |
| 9    | Print String          | DE = .Buffer        | none              |
| 10   | Read Console Buffer   | DE = .Buffer        | see def           |
| 11   | Get Console Status    | none                | A = 00/FF         |
| 12   | Return Version Number | none                | HL = Version*     |
| 13   | Reset Disk System     | none                | see def           |
| 14   | Select Disk           | E = Disk Number     | see def           |
| 15   | Open File             | DE = .FCB           | A = Dir Code      |
| 16   | Close File            | DE = .FCB           | A = Dir Code      |
| 17   | Search for First      | DE = .FCB           | A = Dir Code      |
| 18   | Search for Next       | none                | A = Dir Code      |
| 19   | Delete File           | DE = .FCB           | A = Dir Code      |
| 20   | Read Sequential       | DE = .FCB           | A = Err Code      |
| 21   | Write Sequential      | DE = .FCB           | A = Err Code      |
| 22   | Make File             | DE = .FCB           | A = Dir Code      |
| 23   | Rename File           | DE = .FCB           | A = Dir Code      |
| 24   | Return Login Vector   | none                | HL = Login Vect*  |
| 25   | Return Current Disk   | none                | A = Cur Disk #    |
| 26   | Set DMA Address       | DE = .DMA           | none              |
| 27   | Get Addr(Alloc)       | none                | HL = .Alloc       |
| 28   | Write Protect Disk    | none                | see def           |
| 29   | Get R/O Vector        | none                | HL = R/O Vect*    |
| 30   | Set File Attributes   | DE = .FCB           | see def           |
| 31   | Get Addr (disk parms) | none                | HL = .DPB         |
| 32   | Set/Get User Code     | see def             | see def           |
| 33   | Read Random           | DE = .FCB           | A = Err Code      |
| 34   | Write Random          | DE = .FCB           | A = Err Code      |
| 35   | Compute File Size     | DE = .FCB           | r0, r1, r2        |
| 36   | Set Random Record     | DE = .FCB           | r0, r1, r2        |

\*Note that A = L, and B = H upon return

## **CHAPTER 3**

### **CP/M EDITOR**

- **Introduction to ED**
- **ED Operation**
- **Text Transfer Functions**
- **Memory Buffer Organization**
- **Memory Buffer Operation**
- **Command Strings**
- **Text Search and Alteration**
- **Source Libraries**
- **Repetitive Command Execution**
- **ED Error Conditions**
- **Summary of Control Characters**
- **Summary of ED Commands**
- **ED Text Editing Commands**



# Introduction to ED

ED is the context editor for CP/M, and is used to create and alter CP/M source files. ED is initiated in CP/M by typing

$$\text{ED } \left\{ \begin{array}{l} \langle \text{filename} \rangle \\ \langle \text{filename} \rangle \cdot \langle \text{filetype} \rangle \end{array} \right\}$$

In general, ED reads segments of the source file given by  $\langle \text{filename} \rangle$  or  $\langle \text{filename} \rangle \cdot \langle \text{filetype} \rangle$  into central memory, where the file is manipulated by the operator, and subsequently written back to disk after alterations. If the source file does not exist before editing, it is created by ED and initialized to empty. The overall operation of ED is shown in Figure 1.

## ED Operation

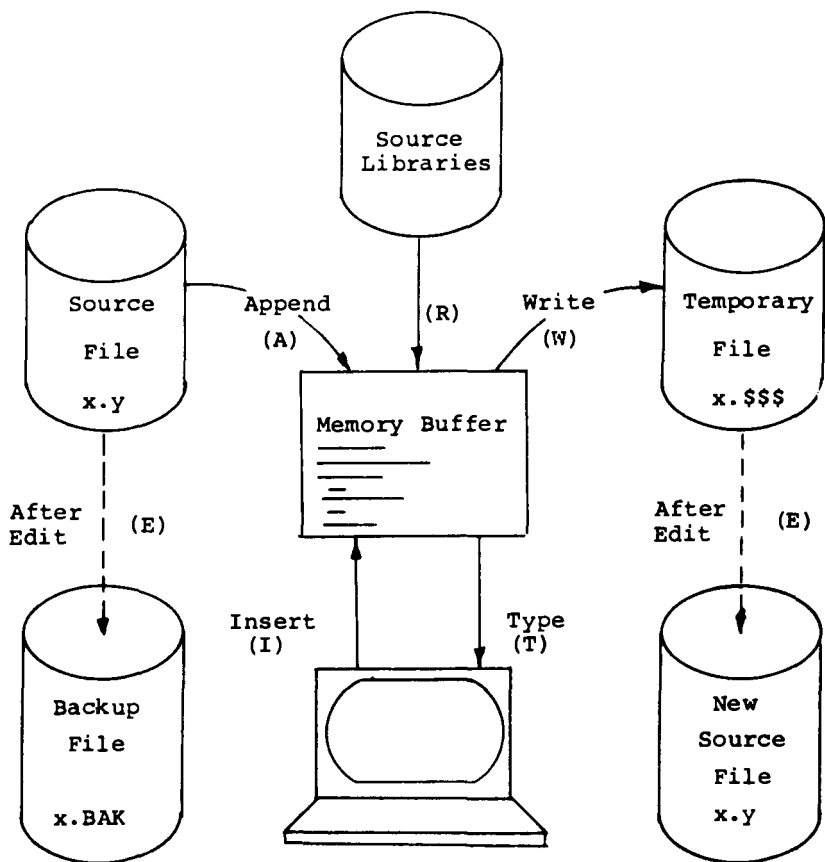
ED operates upon the source file, denoted in Figure 1 by x.y, and passes all text through a memory buffer where the text can be viewed or altered (the number of lines which can be maintained in the memory buffer varies with the line length, but has a total capacity of about 6000 characters in a 16K CP/M system). Text material which has been edited is written onto a temporary work file under command of the operator. Upon termination of the edit, the memory buffer is written to the temporary file, followed by any remaining (unread) text in the source file. The name of the original file is changed from x.y to x.BAK so that the most recent previously edited source file can be reclaimed if necessary (see the CP/M commands ERASE and RENAME). The temporary file is changed from x.\$\$\$ to x.y which becomes the resulting edited file.

The memory buffer is logically between the source file and working file as shown in Figure 2.

## Text Transfer Functions

Given that n is an integer value in the range 0 through 65535, the following ED commands transfer lines of text from the source file through the memory buffer to the temporary (and eventually final) file:

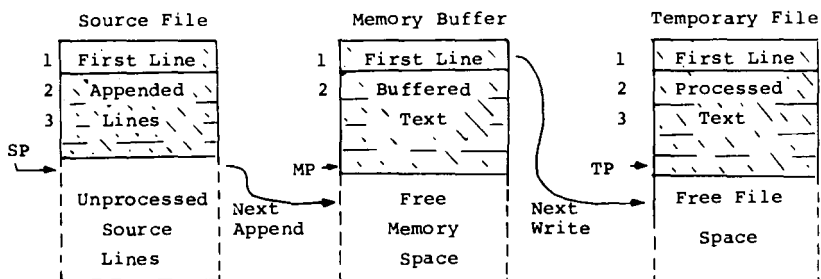
Figure 1. Overall ED Operation



Note: the ED program accepts both lower and upper case ASCII characters as input from the console. Single letter commands can be typed in either case. The U command can be issued to cause ED to translate lower case alphabets to upper case as characters are filled to the memory buffer from the console. Characters are echoed as typed without translation, however. The -U command causes ED to revert to "no translation" mode. ED starts with an assumed -U in effect.

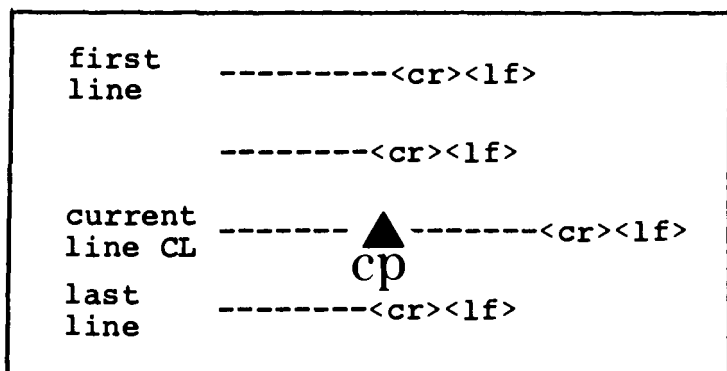


**Figure 2. Memory Buffer Organization**



**Figure 3. Logical Organization of Memory Buffer**

### Memory Buffer



- nA<cr>\*** Append the next n unprocessed source lines from the source file at SP to the end of the memory buffer at MP. Increment SP and MP by n.
- nW<cr>** Write the first n lines of the memory buffer to the temporary file free space. Shift the remaining lines n + 1 through MP to the top of the memory buffer. Increment TP by n.
- E<cr>** End the edit. Copy all buffered text to temporary file, and copy all unprocessed source lines to the temporary file. Rename files as described previously.
- H<cr>** Move to head of new file by performing automatic E command. Temporary file becomes the new source file, the memory buffer is emptied, and a new temporary file is created (equivalent to issuing an E command, followed by a reinvocation of ED using x.y as the file to edit).
- O<cr>** Return to original file. The memory buffer is emptied, the temporary file is deleted, and the SP is returned to position 1 of the source file. The effects of the previous editing commands are thus nullified.
- Q<cr>** Quit edit with no file alterations, return to CP/M.

There are a number of special cases to consider. If the integer n is omitted in any ED command where an integer is allowed, then 1 is assumed. Thus, the commands A and W append one line and write 1 line, respectively. In addition, if a pound sign (#) is given in the place of n, then the integer 65535 is assumed (the largest value for n which is allowed). Since most reasonably sized source files can be contained entirely in the memory buffer, the command #A is often issued at the beginning of the edit to read the entire source file to memory. Similarly, the command #W writes the entire buffer to the temporary file. Two special forms of the A and W commands are provided as a convenience. The command 0A fills the current memory buffer to at least half-full, while 0W writes lines until the buffer is at least half empty. It should also be noted that an error is issued if the memory buffer size is exceeded. The operator may then enter any command (such as W) which does not increase memory requirements. The remainder of any partial line read during the overflow will be brought into memory on the next successful append.

---

\*(<cr>) represents the carriage-return key

## Memory Buffer Organization

The memory buffer can be considered a sequence of source lines brought in with the A command from a source file. The memory buffer has an associated (imaginary) character pointer (CP) which moves throughout the memory buffer under command of the operator. The memory buffer appears logically as shown in Figure 3 where the dashes represent characters of the source line of indefinite length, terminated by carriage return (<cr>) and line feed (<lf>) characters, and ▲ represents the imaginary character pointer. Note that the CP is always located ahead of the first character of the first line, behind the last character of the last line, or between two characters. The current line CL is the source line which contains the CP.

## Memory Buffer Operation

Upon initiation of ED, the memory buffer is empty (i.e., CP is both ahead and behind the first and last character). The operator may either append lines (A command) from the source file, or enter the lines directly from the console with the insert command

I<cr>

ED then accepts any number of input lines, where each line terminates with a <cr> (the <lf> is supplied automatically), until a control-z (denoted by ↑z) is typed by the operator. The CP is positioned after the last character entered. The sequence

```
I<cr>
NOW IS THE<cr>
TIME FOR<cr>
ALL GOOD MEN<cr>
↑z
```

leaves the memory buffer as shown below

```
NOW IS THE<cr><lf>
TIME FOR<cr><lf>
ALL GOOD MEN<cr><lf>▲
```

Various commands can then be issued which manipulate the CP or display source text in the vicinity of the CP. The commands shown below with a preceding n indicate that an optional unsigned value can be specified. When preceded by ±, the command can be unsigned, or have an optional preceding plus or minus sign. As before, the pound sign (#) is replaced by 65535. If an integer n is optional, but not supplied, then n = 1 is assumed. Finally, if a plus sign is optional, but none is specified, then + is assumed.

- $\pm B\langle cr \rangle$     move CP to beginning of memory buffer if +, and to bottom if -.
- $\pm nC\langle cr \rangle$     move CP by  $\pm n$  characters (toward front of buffer if +), counting the  $\langle cr \rangle \langle lf \rangle$  as two distinct characters.
- $\pm nD\langle cr \rangle$     delete  $n$  characters ahead of CP if plus and behind CP if minus.
- $\pm nK\langle cr \rangle$     kill (i.e. remove)  $\pm n$  lines of source text using CP as the current reference. If CP is not at the beginning of the current line when K is issued, then the characters before CP remain if + is specified, while the characters after CP remain if - is given in the command.
- $\pm nL\langle cr \rangle$     if  $n = 0$ , move CP to the beginning of the current line (if it is not already there). If  $n \neq 0$ , first move the CP to the beginning of the current line, and then move it to the beginning of the line which is  $n$  lines down (if +) or up (if -). The CP will stop at the top or bottom of the memory buffer if too large a value is specified.
- $\pm nT\langle cr \rangle$     If  $n = 0$  then type the contents of the current line up to CP. If  $n = 1$  then type the contents of the current line from CP to the end of the line. If  $n > 1$  then type the current line along with  $n-1$  lines which follow, if + is specified. Similarly, if  $n > 1$  and - is given, type the previous  $n$  lines, up to the CP. The break key can be depressed to abort long type-outs.
- $\pm n\langle cr \rangle$     equivalent to  $\pm nLT$ , which moves up or down and types a single line.

## Command Strings

Any number of commands can be typed contiguously (up to the capacity of the CP/M console buffer), and are executed only after the  $\langle cr \rangle$  is typed. Thus, the operator may use the CP/M console command functions to manipulate the input command.

- Rubout        remove the last character
- Control-X    delete the entire line
- Control-C    re-initialize the CP/M System

**Control-E** return carriage for long lines without transmitting buffer  
(max 128 chars)

Suppose the memory buffer contains the characters shown in the previous section, with the CP following the last character of the buffer. The command strings shown below produce the results shown to the right.

| <b>Command String</b>                    | <b>Effect</b>                                                             | <b>Resulting Memory Buffer</b>                                                  |
|------------------------------------------|---------------------------------------------------------------------------|---------------------------------------------------------------------------------|
| B2T<cr>                                  | move to beginning of buffer and type 2 lines:<br>"NOW IS THE<br>TIME FOR" | ▲ <sub>cp</sub> NOW IS THE<cr><lf><br>TIME FOR<cr><lf><br>ALL GOOD MEN<cr><lf>  |
| 5C0T<cr>                                 | move CP 5 characters and type the beginning of the line "NOW I"           | NOW I ▲ <sub>cp</sub> S THE <cr><lf>                                            |
| 2L-T<cr>                                 | move two lines down and type previous line<br>"TIME FOR"                  | NOW IS THE <cr><lf><br>TIME FOR<cr><lf><br>▲ <sub>cp</sub> ALL GOOD MEN<cr><lf> |
| -L#K<cr>                                 | move up one line, delete 65535 lines which follow                         | NOW IS THE<cr><lf>▲ <sub>cp</sub>                                               |
| I<cr><br>TIME TO<cr><br>INSERT<cr><br>↑z | insert two lines of text                                                  | NOW IS THE<cr><lf><br>TIME TO<cr><lf><br>INSERT<cr><lf>▲ <sub>cp</sub>          |
| -2L#T<cr>                                | move up two lines, and type 65535 lines ahead of CP<br>"NOW IS THE"       | NOW IS THE<cr><lf>▲ <sub>cp</sub><br>TIME TO<cr><lf><br>INSERT<cr><lf>          |
| <cr>                                     | move down one line and type one line<br>"INSERT"                          | NOW IS THE<cr><lf><br>TIME TO<cr><lf>▲ <sub>cp</sub><br>INSERT <cr><lf>         |

# Text Search and Alteration

ED also has a command which locates strings within the memory buffer. The command takes the form

$$nF\ c_1c_2\ldots c_k\ \left\{ \begin{array}{c} \langle cr \rangle \\ \uparrow z \end{array} \right\}$$

where  $c_1$  through  $c_k$  represent the characters to match followed by either a  $\langle cr \rangle$  or control  $\uparrow z$ \* ED starts at the current position of CP and attempts to match all  $k$  characters. The match is attempted  $n$  times, and if successful, the CP is moved directly after the character  $c_k$ . If the  $n$  matches are not successful, the CP is not moved from its initial position. Search strings can include  $\uparrow l$  (control-l), which is replaced by the pair of symbols  $\langle cr \rangle \langle lf \rangle$ .

The following commands illustrate the use of the F command:

| Command String            | Effect                                                                                       | Resulting Memory Buffer                                                                                                                                                         |
|---------------------------|----------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| B#T $\langle cr \rangle$  | move to beginning and type entire buffer                                                     | $\uparrow_{cp}$ NOW IS THE $\langle cr \rangle \langle lf \rangle$<br>TIME FOR $\langle cr \rangle \langle lf \rangle$<br>ALL GOOD MEN $\langle cr \rangle \langle lf \rangle$  |
| FS T $\langle cr \rangle$ | find the end of the string "S T"                                                             | NOW IS T $\uparrow_{cp}$ HE $\langle cr \rangle \langle lf \rangle$                                                                                                             |
| FI $\uparrow z$ OTT       | find the next "I" and type to the CP then type the remainder of the current line: "TIME FOR" | NOW IS THE $\langle cr \rangle \langle lf \rangle$<br>TI $\uparrow_{cp}$ ME FOR $\langle cr \rangle \langle lf \rangle$<br>ALL GOOD MEN $\langle cr \rangle \langle lf \rangle$ |

An abbreviated form of the insert command is also allowed, which is often used in conjunction with the F command to make simple textual changes. The form is:

$$I\ c_1c_2\ldots c_n\uparrow z\ \text{or} \\ I\ c_1c_2\ldots c_n\langle cr \rangle$$

where  $c_1$  through  $c_n$  are characters to insert. If the insertion string is terminated by a  $\uparrow z$ , the characters  $c_1$  through  $c_n$  are inserted directly following the CP, and the CP is moved directly after character  $c_n$ . The action is the same if the command is followed by a  $\langle cr \rangle$  except that a  $\langle cr \rangle \langle lf \rangle$  is automatically inserted into the text following character  $c_n$ . Consider the following command sequences as examples of the F and I commands:

\*The control-z is used if additional commands will be typed following the  $\uparrow z$ .

| Command String          | Effect                                                                                                          | Resulting Memory Buffer                                                                             |
|-------------------------|-----------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------|
| BITHIS IS ↑ z⟨cr⟩       | Insert "THIS IS" at the beginning of the text                                                                   | THIS IS <sup>cp</sup> NOW THE⟨cr⟩⟨lf⟩<br>TIME FOR ⟨cr⟩⟨lf⟩<br>ALL GOOD MEN⟨cr⟩⟨lf⟩                  |
| FTIME↑z-4DIPLACE↑z⟨cr⟩  | find "TIME" and delete it; then insert "PLACE"                                                                  | THIS IS NOW THE⟨cr⟩⟨lf⟩<br>PLACE <sup>cp</sup> FOR⟨cr⟩⟨lf⟩<br>ALL GOOD MEN⟨cr⟩⟨lf⟩                  |
| 3FO↑z-3D5DICHANGES↑⟨cr⟩ | find third occurrence of "O" (i.e. the second "O" in GOOD), delete previous 3 characters; then insert "CHANGES" | THIS IS NOW THE⟨cr⟩⟨lf⟩<br>PLACE FOR⟨cr⟩⟨lf⟩<br>ALL CHANGES <sup>cp</sup> ⟨cr⟩⟨lf⟩                  |
| -8CISOURCE⟨cr⟩          | move back 8 characters and insert the line "SOURCE⟨cr⟩⟨lf⟩"                                                     | THIS IS NOW THE⟨cr⟩⟨lf⟩<br>PLACE FOR⟨cr⟩⟨lf⟩<br>ALL SOURCE⟨cr⟩⟨lf⟩<br><sup>cp</sup> CHANGES⟨cr⟩⟨lf⟩ |

ED also provides a single command which combines the F and I commands to perform simple string substitutions. The command takes the form

$$n \text{ S } c_1 c_2 \dots c_k \uparrow z d_1 d_2 \dots d_m \left\{ \begin{array}{c} \langle cr \rangle \\ \uparrow z \end{array} \right\}$$

and has exactly the same effect as applying the command string

$$F \text{ } c_1 c_2 \dots c_k \uparrow z -k D I d_1 d_2 \dots d_m \left\{ \begin{array}{c} \langle cr \rangle \\ \uparrow z \end{array} \right\}$$

a total of  $n$  times. That is, ED searches the memory buffer starting at the current position of CP and successively substitutes the second string for the first string until the end of buffer, or until the substitution has been performed  $n$  times.

As a convenience, a command similar to F is provided by ED which automatically appends and writes lines as the search proceeds. The form is

$$n \text{ N } c_1 c_2 \dots c_k \left\{ \begin{array}{c} \langle cr \rangle \\ \uparrow z \end{array} \right\}$$

which searches the entire source file for the  $n$ th occurrence of the string  $c_1c_2 \dots c_k$  (recall that  $F$  fails if the string cannot be found in the current buffer). The operation of the  $N$  command is precisely the same as  $F$  except in the case that the string cannot be found within the current memory buffer. In this case, the entire memory contents is written (i.e., an automatic  $\#W$  is issued). Input lines are then read until the buffer is at least half full, or the entire source file is exhausted. The search continues in this manner until the string has been found  $n$  times, or until the source file has been completely transferred to the temporary file.

A final line editing function, called the juxtaposition command takes the form

$$n J c_1c_2 \dots c_k \uparrow z \quad d_1d_2 \dots d_m \uparrow z \quad e_1e_2 \dots e_q \left\{ \begin{array}{c} \langle cr \rangle \\ \uparrow z \end{array} \right\}$$

with the following action applied  $n$  times to the memory buffer: search from the current CP for the next occurrence of the string  $c_1c_2 \dots c_k$ . If found, insert the string  $d_1d_2 \dots d_m$ , and move CP to follow  $d_m$ . Then delete all characters following CP up to (but not including) the string  $e_1, e_2, \dots e_q$ , leaving CP directly after  $d_m$ . If  $e_1, e_2, \dots e_q$  cannot be found, then no deletion is made. If the current line is

$\uparrow_{cp}$  NOW IS THE TIME  $\langle cr \rangle \langle lf \rangle$

Then the command

$JW \uparrow z \text{WHAT} \uparrow z \uparrow l \langle cr \rangle$

Results in

NOW WHAT  $\uparrow_{cp} \langle cr \rangle \langle lf \rangle$

(Recall that  $\uparrow l$  represents the pair  $\langle cr \rangle \langle lf \rangle$  in search and substitution strings).

It should be noted that the number of characters allowed by ED in the  $F$ ,  $S$ ,  $N$ , and  $J$  commands is limited to 100 symbols.

## Source Libraries

ED also allows the inclusion of source libraries during the editing process with the  $R$  command. The form of this command is



$R f_1 f_2 \dots f_n \uparrow z$       or

$R f_1 f_2 \dots f_n \langle cr \rangle$

where  $f_1 f_2 \dots f_n$  is the name of a source file on the disk with an assumed filetype of 'LIB'. ED reads the specified file, and places the characters into the memory buffer after CP, in a manner similar to the I command. Thus, if the command

$R MACRO \langle cr \rangle$

is issued by the operator, ED reads from the file MACRO.LIB until the end-of-file, and automatically inserts the characters into the memory buffer.

## Repetitive Command Execution

The macro command M allows the ED user to group ED commands together for repeated evaluation. The M command takes the form:

$$n \ M \ c_1 c_2 \dots c_k \left\{ \begin{array}{c} \langle cr \rangle \\ \uparrow z \end{array} \right\}$$

where  $c_1 c_2 \dots c_k$  represent a string of ED commands, not including another M command. ED executes the command string  $n$  times if  $n > 1$ . If  $n = 0$  or 1, the command string is executed repetitively until an error condition is encountered (e.g., the end of the memory buffer is reached with an F command).

As an example, the following macro changes all occurrences of GAMMA to DELTA within the current buffer, and types each line which is changed:

$MFGAMMA \uparrow z - 5 D I DELTA \uparrow z 0 TT \langle cr \rangle$

or equivalently

$MSGAMMA \uparrow z DELTA \uparrow z 0 TT \langle cr \rangle$

## ED Error Conditions

On error conditions, ED prints the last character read before the error, along with an error indicator:

?      unrecognized command

- > memory buffer full (use one of the commands D, K, N, S, or W to remove characters), F, N, or S strings too long.
- # cannot apply command the number of times specified (e.g., in F command)
- O cannot open LIB file in R command

Cyclic redundancy check (CRC) information is written with each output record under CP/M in order to detect errors on subsequent read operations. If a CRC error is detected, CP/M will type

PERM ERR DISK d

where d is the currently selected drive (A, B, . . .). The operator can choose to ignore the error by typing any character at the console (in this case, the memory buffer data should be examined to see if it was incorrectly read), or the user can reset the system and reclaim the backup file, if it exists. The file can be reclaimed by first typing the contents of the BAK file to ensure that it contains the proper information:

TYPE x.BAK<cr>

where x is the file being edited. Then remove the primary file:

ERA x.y<cr>

and rename the BAK file:

REN x.y=x.BAK<cr>

The file can then be re-edited, starting with the previous version.

## Summary of Control Characters

The following table summarizes the Control characters and commands available in ED:

| Control Character | Function |
|-------------------|----------|
|-------------------|----------|

|    |               |
|----|---------------|
| ↑c | system reboot |
|----|---------------|

|    |                                                     |
|----|-----------------------------------------------------|
| ↑e | physical <cr><lf> (not actually entered in command) |
|----|-----------------------------------------------------|

|               |                                                   |
|---------------|---------------------------------------------------|
| <b>↑i</b>     | logical tab (cols 1, 8, 15, . . . )               |
| <b>↑l</b>     | logical <cr><lf> in search and substitute strings |
| <b>↑x</b>     | line delete                                       |
| <b>↑z</b>     | string terminator                                 |
| <b>rubout</b> | character delete                                  |
| <b>break</b>  | discontinue command (e.g., stop typing)           |

## Summary of ED Commands

| <b>Command</b> | <b>Function</b>                       |
|----------------|---------------------------------------|
| <b>nA</b>      | append lines                          |
| <b>± B</b>     | begin bottom of buffer                |
| <b>± nC</b>    | move character positions              |
| <b>± nD</b>    | delete characters                     |
| <b>E</b>       | end edit and close files (normal end) |
| <b>nF</b>      | find string                           |
| <b>H</b>       | end edit, close and reopen files      |
| <b>I</b>       | insert characters                     |
| <b>nJ</b>      | place strings in juxtaposition        |
| <b>± nK</b>    | kill lines                            |
| <b>± nL</b>    | move down/up lines                    |
| <b>nM</b>      | macro definition                      |
| <b>nN</b>      | find next occurrence with autoscan    |

|                           |                                                          |
|---------------------------|----------------------------------------------------------|
| O                         | return to original file                                  |
| $\pm nP$                  | move and print pages                                     |
| Q                         | quit with no file changes                                |
| R                         | read library file                                        |
| nS                        | substitute strings                                       |
| $\pm nT$                  | type lines                                               |
| - U                       | translate lower to upper case if U, no translation if -U |
| nW                        | write lines                                              |
| nZ                        | sleep                                                    |
| $\pm n\langle cr \rangle$ | move and type ( $\pm nLT$ )                              |

## ED Text Editing Commands

The ED context editor contains a number of commands which enhance its usefulness in text editing. The improvements are found in the addition of line numbers, free space interrogation, and improved error reporting.

The context editor issued with CP/M produces absolute line number prefixes when the "V" (Verify Line Numbers) command is issued. Following the V command, the line number is displayed ahead of each line in the format:

nnnnn:

where nnnnn is an absolute line number in the range 1 to 65535. If the memory buffer is empty, or if the current line is at the end of the memory buffer, then nnnnn appears as 5 blanks.

The user may reference an absolute line number by preceding any command by a number followed by a colon, in the same format as the line number display. In this case, the ED program moves the current line reference to the absolute line number, if the line exists in the current memory buffer. Thus the command

345:T

is interpreted as “move to absolute line 345, and type the line.” Note that absolute line numbers are produced only during the editing process, and are not recorded with the file. In particular, the line numbers will change following a deleted or expanded section of text.

The user may also reference an absolute line number as a backward or forward distance from the current line by preceding the absolute line number by a colon. Thus, the command

:400T

is interpreted as “type from the current line number through the line whose absolute number is 400.” Combining the two line reference forms, the command

345::400T

for example, is interpreted as “move to absolute line 345, then type through absolute line 400.” Note that absolute line references of this sort can precede any of the standard ED commands.

A special case of the V command, “0V,” prints the memory buffer statistics in the form:

free/total

where “free” is the number of free bytes in the memory buffer (in decimal), and “total” is the size of the memory buffer.

ED also includes a “block move” facility implemented through the “X” (Xfer) command. The form

nX

transfers the next n lines from the current line to a temporary file called

X\$\$\$\$\$\$\$.LIB

which is active only during the editing process. In general, the user can reposition the current line reference to any portion of the source file and transfer lines to the temporary file. The transferred lines accumulate one after another in this file, and can be retrieved by simply typing:

## R

which is the trivial case of the library read command. In this case, the entire transferred set of lines is read into the memory buffer. Note that the X command does not remove the transferred lines from the memory buffer, although a K command can be used directly after the X, and the R command does not empty the transferred line file. That is, given that a set of lines has been transferred with the X command, they can be re-read any number of times back into the source file. The command

## 0X

is provided, however, to empty the transferred line file.

Note that upon normal completion of the ED program through Q or E, the temporary LIB file is removed. If ED is aborted through Control-C, the LIB file will exist if lines have been transferred, but will generally be empty (a subsequent ED invocation will erase the temporary file).

Due to common typographical errors, ED requires several potentially disastrous commands to be typed as single letters, rather than in composite commands. The commands

E (end), H (head), O (original), Q (quit)

must be typed as single letter commands.

ED also prints error messages in the form

BREAK "x" AT c

where x is the error character, and c is the command where the error occurred.

## **CHAPTER 4**

### **CP/M Assembler**

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# Introduction

The CP/M assembler reads assembly language source files from the diskette, and produces 8080 machine language in Intel hex format. The CP/M assembler is initiated by typing

ASM filename

or

ASM filename.parms

In both cases, the assembler assumes there is a file on the diskette with the name

filename.ASM

which contains an 8080 assembly language source file. The first and second forms shown above differ only in that the second form allows parameters to be passed to the assembler to control source file access and hex and print file destinations.

In either case, the CP/M assembler loads, and prints the message

CP/M ASSEMBLER VER n.n

where n.n is the current version number. In the case of the first command, the assembler reads the source file with assumed file type "ASM" and creates two output files.

filename.HEX

and

filename.PRN

The "HEX" file contains the machine code corresponding to the original program in Intel hex format, and the "PRN" file contains an annotated listing showing generated machine code, error flags, and source lines. If errors occur during translation, they will be listed in the PRN file as well as at the console.

The second command form can be used to redirect input and output files from their defaults. In this case, the "parms" portion of the command is a three letter group which specifies the origin of the source file, the destination of the hex file, and the destination of the print file. The form is

filename.plp2p3

where p1, p2, and p3 are single letters

p1: A,B, ..., Y    designates the disk name which contains  
the source file

p2: A,B, ..., Y    designates the disk name which will receive  
the hex file  
Z                    skips the generation of the hex file

p3: A,B, ..., Y    designates the disk name which will receive  
the print file  
X                    places the listing at the console  
Z                    skips generation of the print file

Thus, the command

ASM X.AAA

indicates that the source file (X.ASM) is to be taken from disk A, and that the hex (X.HEX) and the print (X.PRN) files are to be created also on disk A. This form of the command is implied if the assembler is run from disk A. That is, given that the operator is currently addressing disk A, the above command is equivalent to

ASM X

The command

ASM X.ABX

indicates that the source file is to be taken from disk A, the hex file is placed on disk B, and the listing file is to be sent to the console. The command

ASM X.BZZ

takes the source file from disk B, and skips the generation of the hex and print files. (This command is useful for fast execution of the assembler to check program syntax.)

The source program format is compatible with both the Intel 8080 assembler (macros are not currently implemented in the CP/M assembler, however), as well as the Processor Technology Software Package #1 assembler. That is, the CP/M assembler accepts source programs written in either format. There are certain extensions in the CP/M assembler which make it somewhat easier to use. These extensions are described below.

# Program Format

An assembly language program acceptable as input to the assembler consists of a sequence of statements of the form

line# label operation operand ;comment

where any or all of the fields may be present in a particular instance. Each assembly language statement is terminated with a carriage return and line feed (the line feed is inserted automatically by the ED program), or with the character "!" which is treated as an end-of-line by the assembler (thus, multiple assembly language statements can be written on the same physical line if separated by exclamation symbols).

The line# is an optional decimal integer value representing the source program line number, which is allowed on any source line to maintain compatibility with the Processor Technology format. In general, these line numbers will be inserted if a line-oriented editor is used to construct the original program, and thus ASM ignores this field if present.

The label field takes the form

identifier

or

identifier:

and is optional, except where noted in particular statement types. The identifier is a sequence of alphanumeric characters (alphabets and numbers), where the first character is alphabetic. Identifiers can be freely used by the programmer to label elements such as program steps and assembler directives, but cannot exceed 16 characters in length. All characters are significant in an identifier, except for the embedded dollar symbol (\$) which can be used to improve readability of the name. Further, all lower case alphabets are treated as if they were upper case. Note that the ":" following the identifier in a label is optional (to maintain compatibility between Intel and Processor Technology). Thus, the following are all valid instances of labels

|         |         |                         |
|---------|---------|-------------------------|
| x       | x y     | long\$name              |
| x:      | y x 1:  | longer\$name\$data:     |
| X 1 Y 2 | X 1 x 2 | x234\$5678\$9012\$3456: |

The operation field contains either an assembler directive, or pseudo operation, or an 8080 machine operation code. The pseudo operations and machine operation codes are described below.

The operand field of the statement, in general, contains an expression formed out of constants and labels, along with arithmetic and logical operations on these elements. Again, the complete details of properly formed expressions are given below.

The comment field contains arbitrary characters following the “;” symbol until the next real or logical end-of-line. These characters are read, listed, and otherwise ignored by the assembler. In order to maintain compatibility with the Processor Technology assembler, the CP/M assembler also treats statements which begin with a “\*” in column one as comment statements, which are listed and ignored in the assembly process. Note that the Processor Technology assembler has the side effect in its operation of ignoring the characters after the operand field has been scanned. This causes an ambiguous situation when attempting to be compatible with Intel’s language, since arbitrary expressions are allowed in this case. Hence, programs which use this side effect to introduce comments, must be edited to place a “;” before these fields in order to assemble correctly.

The assembly language program is formulated as a sequence of statements of the above form, terminated optionally by an END statement. All statements following the END are ignored by the assembler.

## Forming the Operand

In order to completely describe the operation codes and pseudo operations, it is necessary to first present the form of the operand field, since it is used in nearly all statements. Expressions in the operand field consist of simple operands (labels, constants, and reserved words), combined in properly formed subexpressions by arithmetic and logical operators. The expression computation is carried out by the assembler as the assembly proceeds. Each expression must produce a 16-bit value during the assembly. Further, the number of significant digits in the result must not exceed the intended use. That is, if an expression is to be used in a byte move immediate instruction, then the most significant 8 bits of the expression must be zero. The restrictions on the expression significance are given with the individual instructions.

### Labels

As discussed above, a label is an identifier which occurs on a particular statement. In general, the label is given a value determined by the type of statement which it precedes. If the label occurs on a statement which generates machine code or reserves memory space (e.g. a MOV instruction, or a DS pseudo operation), then the label is given the value of the program address which it labels. If the label precedes an EQU or SET, then the label

is given the value which results from evaluating the operand field. Except for the SET statement, an identifier can label only one statement.

When a label appears in the operand field, its value is substituted by the assembler. This value can then be combined with other operands and operators to form the operand field for a particular instruction.

## Numeric Constants

A numeric constant is a 16-bit value in one of several bases. The base, called the radix of the constant, is denoted by a trailing radix indicator. The radix indicators are

|   |                                |
|---|--------------------------------|
| B | binary constant (base 2)       |
| O | octal constant (base 8)        |
| Q | octal constant (base 8)        |
| D | decimal constant (base 10)     |
| H | hexadecimal constant (base 16) |

Q is an alternate radix indicator for octal numbers since the letter O is easily confused with the digit 0. Any numeric constant which does not terminate with a radix indicator is assumed to be a decimal constant.

A constant is thus composed as a sequence of digits, followed by an optional radix indicator, where the digits are in the appropriate range for the radix. That is binary constants must be composed of 0 and 1 digits, octal constants can contain digits in the range 0 - 7, while decimal constants contain decimal digits. Hexadecimal constants contain decimal digits as well as hexadecimal digits A (10D), B (11D), C (12D), D (13D), E (14D), and F (15D). Note that the leading digit of a hexadecimal constant must be a decimal digit in order to avoid confusing a hexadecimal constant with an identifier (a leading 0 will always suffice). A constant composed in this manner must evaluate to a binary number which can be contained within a 16-bit counter, otherwise it is truncated on the right by the assembler. Similar to identifiers, imbedded "\$" are allowed within constants to improve their readability. Finally, the radix indicator is translated to upper case if a lower case letter is encountered. The following are all valid instances of numeric constants

|       |       |       |                         |
|-------|-------|-------|-------------------------|
| 1234  | 1234D | 1100B | 1111\$0000\$1111\$0000B |
| 1234H | 0FFEH | 3377O | 33\$77\$22Q             |
| 3377o | 0fe3h | 1234d | 0ffffh                  |

## Reserved Words

There are several reserved character sequences which have predefined meanings in the operand field of a statement. The names of 8080 registers are given below, which, when encountered, produce the value shown to the right.

|     |   |
|-----|---|
| A   | 7 |
| B   | 0 |
| C   | 1 |
| D   | 2 |
| E   | 3 |
| H   | 4 |
| L   | 5 |
| M   | 6 |
| SP  | 6 |
| PSW | 6 |

(Again, lower case names have the same values as their upper case equivalents.) Machine instructions can also be used in the operand field, and evaluate to their internal codes. In the case of instructions which require operands, where the specific operand becomes a part of the binary bit pattern of the instruction (e.g. MOV A,B), the value of the instruction (in this case MOV) is the bit pattern of the instruction with zeroes in the optional fields (e.g. MOV produces 40H).

When the symbol "\$" occurs in the operand field (not imbedded within identifiers and numeric constants) its value becomes the address of the next instruction to generate, not including the instruction contained within the current logical line.

## String Constants

String constants represent sequences of ASCII characters, and are represented by enclosing the characters within apostrophe symbols ('). All strings must be fully contained within the current physical line (thus allowing "!" symbols within strings), and must not exceed 64 characters in length. The apostrophe character itself can be included within a string by representing it as a double apostrophe (the two keystrokes "), which becomes a single apostrophe when read by the assembler. In most cases, the string length is restricted to either one or two characters (the DB pseudo operation is an exception), in which case the string becomes an 8 or 16 bit value, respectively. Two character strings become a 16-bit constant, with the second character as the low order byte, and the first character as the high order byte.

The value of a character is its corresponding ASCII code. There is no case translation within strings, and thus both upper and lower case characters can be represented. Note however, that only graphic (printing) ASCII characters are allowed within strings. Valid strings are

```
'A'      'AB'      'ab'      'c'
'''      'a'''     ''''     '''''
'Walla Walla Wash.'
'She said "Hello" to me.'
'I said "Hello" to her.'
```

## Arithmetic and Logical Operators

The operands described above can be combined in normal algebraic notation using any combination of properly formed operands, operators, and parenthesized expressions. The operators recognized in the operand field are

|                    |                                                                                                 |
|--------------------|-------------------------------------------------------------------------------------------------|
| $a + b$            | unsigned arithmetic sum of a and b                                                              |
| $a - b$            | unsigned arithmetic difference between a and b                                                  |
| $+ b$              | unary plus (produces b)                                                                         |
| $- b$              | unary minus (identical to $0 - b$ )                                                             |
| $a * b$            | unsigned magnitude multiplication of a and b                                                    |
| $a / b$            | unsigned magnitude division of a by b                                                           |
| $a \text{ MOD } b$ | remainder after $a / b$                                                                         |
| $\text{NOT } b$    | logical inverse of b (all 0's become 1's, 1's become 0's), where b is considered a 16-bit value |
| $a \text{ AND } b$ | bit-by-bit logical and of a and b                                                               |
| $a \text{ OR } b$  | bit-by-bit logical or of a and b                                                                |
| $a \text{ XOR } b$ | bit-by-bit logical exclusive or of a and b                                                      |
| $a \text{ SHL } b$ | the value which results from shifting a to the left by an amount b, with zero fill              |
| $a \text{ SHR } b$ | the value which results from shifting a to the right by an amount b, with zero fill             |

In each case, a and b represent simple operands (labels, numeric constants, reserved words, and one or two character strings), or fully enclosed parenthesized subexpressions such as

```
10 + 20      10h + 37Q      L1 / 3  (L2 + 4) SHR 3
('a' and 5fh) + '0'      ('B' + B) OR (PSW + M)
(1 + (2 + c)) shr (A - (B + 1))
```

Note that all computations are performed at assembly time as 16-bit unsigned operations. Thus, -1 is computed as 0-1 which results in the value 0ffffh (i.e., all 1's). The resulting expression must fit the operation code in which it is used. If, for example, the expression is used in a ADI (add

immediate) instruction, then the high order eight bits of the expression must be zero. As a result, the operation "ADI -1" produces an error message (-1 becomes 0ffffh which cannot be represented as an 8 bit value), while "ADI (-1) AND 0FFH" is accepted by the assembler since the "AND" operation zeroes the high order bits of the expression.

## Precedence of Operators

As a convenience to the programmer, ASM assumes that operators have a relative precedence of application which allows the programmer to write expressions without nested levels of parentheses. The resulting expression has assumed parentheses which are defined by the relative precedence. The order of application of operators in unparenthesized expressions is listed below. Operators listed first have highest precedence (they are applied first in an unparenthesized expression), while operators listed last have lowest precedence. Operators listed on the same line have equal precedence, and are applied from left to right as they are encountered in an expression

\* / MOD SHL SHR  
- +  
NOT  
AND  
OR XOR

Thus, the expressions shown to the left below are interpreted by the assembler as the fully parenthesized expressions shown to the right below

|                            |                                    |
|----------------------------|------------------------------------|
| a * b + c                  | (a * b) + c                        |
| a + b * c                  | a + (b * c)                        |
| a MOD b * c SHL d          | ((a MOD b) * c) SHL d              |
| a OR b AND NOT c + d SHL e | a OR (b AND (NOT (c + (d SHL e)))) |

Balanced parenthesized subexpressions can always be used to override the assumed parentheses, and thus the last expression above could be rewritten to force application of operators in a different order as

(a OR b) AND (NOT c) + d SHL e

resulting in the assumed parentheses

(a OR b) AND ((NOT c) + (d SHL e))



Note that an unparenthesized expression is well-formed only if the expression which results from inserting the assumed parentheses is well-formed.

## Assembler Directives

Assembler directives are used to set labels to specific values during the assembly, perform conditional assembly, define storage areas, and specify starting addresses in the program. Each assembler directive is denoted by a "pseudo operation" which appears in the operation field of the line. The acceptable pseudo operations are

|       |                                     |
|-------|-------------------------------------|
| ORG   | set the program or data origin      |
| END   | end program, optional start address |
| EQU   | numeric "equate"                    |
| SET   | numeric "set"                       |
| IF    | begin conditional assembly          |
| ENDIF | end of conditional assembly         |
| DB    | define data bytes                   |
| DW    | define data words                   |
| DS    | define data storage area            |

### The ORG Directive

The ORG statement takes the form

label      ORG      expression

where "label" is an optional program label, and expression is a 16-bit expression, consisting of operands which are defined previous to the ORG statement. The assembler begins machine code generation at the location specified in the expression. There can be any number of ORG statements within a particular program, and there are no checks to ensure that the programmer is not defining overlapping memory areas. Note that most programs written for the CP/M system begin with an ORG statement of the form

ORG 100H

which causes machine code generation to begin at the base of the CP/M transient program area. If a label is specified in the ORG statement, then the label is given the value of the expression (this label can then be used in the operand field of other statements to represent this expression).

## The END Directive

The END statement is optional in an assembly language program, but if it is present it must be the last statement (all subsequent statements are ignored in the assembly). The two forms of the END directive are

```
label    END
label    END    expression
```

where the label is again optional. If the first form is used, the assembly process stops, and the default starting address of the program is taken as 0000. Otherwise, the expression is evaluated, and becomes the program starting address (this starting address is included in the last record of the Intel formatted machine code "hex" file which results from the assembly). Thus, most CP/M assembly language programs end with the statement

```
END 100H
```

resulting in the default starting address of 100H (beginning of the transient program area).

## The EQU Directive

The EQU (equate) statement is used to set up synonyms for particular numeric values. The form is

```
label    EQU    expression
```

where the label must be present, and must not label any other statement. The assembler evaluates the expression, and assigns this value to the identifier given in the label field. The identifier is usually a name which describes the value in a more human-oriented manner. Further, this name is used throughout the program to "parameterize" certain functions. Suppose for example, that data received from a Teletype appears on a particular input port, and data is sent to the Teletype through the next output port in sequence. The series of equate statements could be used to define these ports for a particular hardware environment

```
TTYBASE EQU 10H          ;BASE PORT NUMBER FOR TTY
TTYIN    EQU TTYBASE     ;TTY DATA IN
TTYOUT   EQU TTYBASE+1   ;TTY DATA OUT
```

At a later point in the program, the statements which access the Teletype could appear as

```

IN   TTYIN      ;READ TTY DATA TO REG - A
...
OUT  TTYOUT     ;WRITE DATA TO TTY FROM REG-A

```

making the program more readable than if the absolute I/O ports had been used. Further, if the hardware environment is redefined to start the Teletype communications ports at 7FH instead of 10H, the first statement need only be changed to

```
TTYBASE EQU 7FH      ;BASE PORT NUMBER FOR TTY
```

and the program can be reassembled without changing any other statements.

## The SET Directive

The SET statement is similar to the EQU, taking the form

```
label    SET    expression
```

except that the label can occur on other SET statements within the program. The expression is evaluated and becomes the current value associated with the label. Thus, the EQU statement defines a label with a single value, while the SET statement defines a value which is valid from the current SET statement to the point where the label occurs on the next SET statement. The use of the SET is similar to the EQU statement, but is used most often in controlling conditional assembly.

## The IF and ENDIF Directives

The IF and ENDIF statements define a range of assembly language statements which are to be included or excluded during the assembly process. The form is

```

IF  expression
statement #1
statement #2
...
statement #n
ENDIF

```

Upon encountering the IF statement, the assembler evaluates the expression following the IF (all operands in the expression must be defined ahead of the IF statement). If the expression evaluates to a non-zero value, then statement #1 through statement #n are assembled; if the expression

evaluates to zero, then the statements are listed but not assembled. Conditional assembly is often used to write a single "generic" program which includes a number of possible run-time environments, with only a few specific portions of the program selected for any particular assembly. The following program segments for example, might be part of a program which communicates with either a Teletype or a CRT console (but not both) by selecting a particular value for TTY before the assembly begins

```

TRUE      EQU  0FFFFH      ;DEFINE VALUE OF TRUE
FALSE     EQU  NOT TRUE    ;DEFINE VALUE OF FALSE
;
TTY       EQU  TRUE        ;TRUE IF TTY, FALSE IF CRT
;
TTYBASE   EQU  10H         ;BASE OF TTY I/O PORTS
CRTBASE   EQU  20H         ;BASE OF CRT I/O PORTS
          IF  TTY          ;ASSEMBLE RELATIVE TO
                          TTYBASE
CONIN     EQU  TTYBASE      ;CONSOLE INPUT
CONOUT    EQU  TTYBASE+1    ;CONSOLE OUTPUT
          ENDIF
;
          IF  NOT TTY      ;ASSEMBLE RELATIVE TO
                          CRTBASE
CONIN     EQU  CRTBASE      ;CONSOLE INPUT
CONOUT    EQU  CRTBASE+1    ;CONSOLE OUTPUT
          ENDIF
...
IN        CONIN            ;READ CONSOLE DATA
...
OUT       CONOUT           ;WRITE CONSOLE DATA

```

In this case, the program would assemble for an environment where a Teletype is connected, based at port 10H. The statement defining TTY could be changed to

```
TTY      EQU  FALSE
```

and, in this case, the program would assemble for a CRT based at port 20H.

## The DB Directive

The DB directive allows the programmer to define initialized storage areas in single precision (byte) format. The statement form is

```
label    DB    e#1, e#2, ..., e#n
```

where  $e\#1$  through  $e\#n$  are either expressions which evaluate to 8-bit values (the high order eight bits must be zero), or are ASCII strings of length no greater than 64 characters. There is no practical restriction on the number of expressions included on a single source line. The expressions are evaluated and placed sequentially into the machine code file following the last program address generated by the assembler. String characters are similarly placed into memory starting with the first character and ending with the last character. Strings of length greater than two characters cannot be used as operands in more complicated expressions (i.e., they must stand alone between the commas). Note that ASCII characters are always placed in memory with the parity bit reset (0). Further, recall that there is no translation from lower to upper case within strings. The optional label can be used to reference the data area throughout the remainder of the program. Examples of valid DB statements are

```
data:      DB  0,1,2,3,4,5
           DB  data and 0ffh,5,377Q,1 + 2 + 3 + 4
signon:    DB  'please type your name',cr,lf,0
           DB  'AB' SHR 8, 'C', 'DE' AND 7FH
```

## The DW Directive

The DW statement is similar to the DB statement except double precision (two byte) words of storage are initialized. The form is

```
label      DW      e#1, e#2, ..., e#n
```

where  $e\#1$  through  $e\#n$  are expressions which evaluate to 16-bit results. Note that ASCII strings of length one or two characters are allowed, but strings longer than two characters disallowed. In all cases, the data storage is consistent with the 8080 processor: the least significant byte of the expression is stored first in memory, followed by the most significant byte. Examples are

```
doub:      DW      0ffeh,doub + 4,signon-$,255 + 255
           DW      'a', 5, 'ab', 'CD', 6 shl 8 or 11b
```

## The DS Directive

The DS statement is used to reserve an area of uninitialized memory, and takes the form

```
label      DS      expression
```

where the label is optional. The assembler begins subsequent code generation after the area reserved by the DS. Thus, the DS statement given above has exactly the same effect as the statement

label: EQU \$ ;LABEL VALUE IS CURRENT CODE LOCATION  
 ORG \$ + expression ;MOVE PAST RESERVED AREA

## Operation Codes

Assembly language operation codes form the principal part of assembly language programs, and form the operation field of the instruction. In general, ASM accepts all the standard mnemonics for the Intel 8080 microcomputer, which are given in detail in the Intel manual *8080 Assembly Language Programming Manual*. Labels are optional on each input line and, if included, take the value of the instruction address immediately before the instruction is issued. The individual operators are listed briefly in the following sections for completeness, although it is understood that the Intel manuals should be referenced for exact operator details. In each case,

- e3 represents a 3-bit value in the range of 0-7 which can be one of the predefined registers A, B, C, D, E, H, L, M, SP, or PSW.
- e8 represents an 8-bit value in the range 0-255
- e16 represents a 16-bit value in the range 0-65535

which can themselves be formed from an arbitrary combination of operands and operators. In some cases, the operands are restricted to particular values within the allowable range, such as the PUSH instruction. These cases will be noted as they are encountered.

In the sections which follow, each operation code is listed in its most general form, along with a specific example, with a short explanation and special restrictions.

### Jumps, Calls and Returns

The Jump, Call and Return instructions allow several different forms which test the condition flags set in the 8080 microcomputer CPU. The forms are

|     |     |     |        |                                     |
|-----|-----|-----|--------|-------------------------------------|
| JMB | e16 | JMP | L1     | Jump unconditionally to label       |
| JNZ | e16 | JMP | L2     | Jump on non zero condition to label |
| JZ  | e16 | JMP | 100H   | Jump on zero condition to label     |
| JNC | e16 | JNC | L1 + 4 | Jump no carry to label              |
| JC  | e16 | JC  | L3     | Jump on carry to label              |
| JPO | e16 | JPO | \$ + 8 | Jump on parity odd to label         |
| JPE | e16 | JPE | L4     | Jump on even parity to label        |
| JP  | e16 | JP  | GAMMA  | Jump on positive result to label    |

|      |     |      |        |                                                                        |
|------|-----|------|--------|------------------------------------------------------------------------|
| JM   | e16 | JM   | al     | Jump on minus to label                                                 |
| CALL | e16 | CALL | S1     | Call subroutine unconditionally                                        |
| CNZ  | e16 | CNZ  | S2     | Call subroutine if non zero flag                                       |
| CZ   | e16 | CZ   | 100H   | Call subroutine on zero flag                                           |
| CNC  | e16 | CNC  | S1+4   | Call subroutine if no carry set                                        |
| CC   | e16 | CC   | S3     | Call subroutine if carry set                                           |
| CPO  | e16 | CPO  | \$+8   | Call subroutine if parity odd                                          |
| CPE  | e16 | CPE  | S4     | Call subroutine if parity even                                         |
| CP   | e16 | CP   | GAMMA  | Call subroutine if positive result                                     |
| CM   | e16 | CM   | b1\$c2 | Call subroutine if minus flag                                          |
|      |     |      |        |                                                                        |
| RST  | e3  | RST  | 0      | Programmed “restart,” equivalent to<br>CALL 8*e3, except one byte call |
|      |     |      |        |                                                                        |
| RET  |     |      |        | Return from subroutine                                                 |
| RNZ  |     |      |        | Return if non zero flag set                                            |
| RZ   |     |      |        | Return if zero flag set                                                |
| RNC  |     |      |        | Return if no carry                                                     |
| RC   |     |      |        | Return if carry flag set                                               |
| RPO  |     |      |        | Return if parity is odd                                                |
| RPE  |     |      |        | Return if parity is even                                               |
| RP   |     |      |        | Return if positive result                                              |
| RM   |     |      |        | Return if minus flag is set                                            |

## Immediate Operand Instructions

Several instructions are available which load single or double precision registers, or single precision memory cells, with constant values, along with instructions which perform immediate arithmetic or logical operations on the accumulator (register A).

|           |     |             |                                                                       |
|-----------|-----|-------------|-----------------------------------------------------------------------|
| MVI e3,e8 | MVI | B,255       | Move immediate data to register A,<br>B, C, D, E, H, L, or M (memory) |
| ADI e8    | ADI | 1           | Add immediate operand to A with-<br>out carry                         |
| ACI e8    | ACI | 0FFH        | Add immediate operand to A with<br>carry                              |
| SUI e8    | SUI | L + 3       | Subtract from A without borrow<br>(carry)                             |
| SBI e8    | SBI | L AND 11B   | Subtract from A with borrow (carry)                                   |
| ANI e8    | ANI | \$ AND 7FH  | Logical “and” A with immediate<br>data                                |
| XRI e8    | XRI | 1111\$0000B | “Exclusive or” A with immediate<br>data                               |
| ORI e8    | ORI | L AND 1+1   | Logical “or” A with immediate data                                    |

|            |            |                                                                                  |
|------------|------------|----------------------------------------------------------------------------------|
| CPI e8     | CPI 'a'    | Compare A with immediate data (same as SUI except register A not changed)        |
| LXI e3,e16 | LXI B,100H | Load extended immediate to register pair (e3 must be equivalent to B,D,H, or SP) |

### Increment and Decrement Instructions

Instructions are provided in the 8080 repertoire for incrementing or decrementing single and double precision registers. The instructions are

|        |        |                                                                                  |
|--------|--------|----------------------------------------------------------------------------------|
| INR e3 | INR E  | Single precision increment register (e3 produces one of A, B, C, D, E, H, L, M)  |
| DCR e3 | DCR A  | Single precision decrement register (e3 produces one of A, B, C, D, E, H, L, M)  |
| INX e3 | INX SP | Double precision increment register pair (e3 must be equivalent to B,D,H, or SP) |
| DCX e3 | DCX B  | Double precision decrement register pair (e3 must be equivalent to B,D,H, or SP) |

### Data Movement Instructions

Instructions which move data from memory to the CPU and from CPU to memory are given below

|           |             |                                                                                                                            |
|-----------|-------------|----------------------------------------------------------------------------------------------------------------------------|
| MOV e3,e3 | MOV A,B     | Move data to leftmost element from rightmost element (e3 produces one of A, B, C, D, E, H, L, or M). MOV M,M is disallowed |
| LDAX e3   | LDAX B      | Load register A from computed address (e3 must produce either B or D)                                                      |
| STAX e3   | STAX D      | Store register A to computed address (e3 must produce either B or D)                                                       |
| LHLD e16  | LHLD L1     | Load HL direct from location e16 (double precision load to H and L)                                                        |
| SHLD e16  | SHLD L5 + x | Store HL direct to location e16 (double precision store from H and L to memory)                                            |



|         |           |                                                                                 |
|---------|-----------|---------------------------------------------------------------------------------|
| LDA e16 | LDA Gamma | Load register A from address e16                                                |
| STA e16 | STA X3-5  | Store register A into memory at e16                                             |
| POP e3  | POP PSW   | Load register pair from stack, set SP (e3 must produce one of B, D, H, or PSW)  |
| PUSH e3 | PUSH B    | Store register pair into stack, set SP (e3 must produce one of B, D, H, or PSW) |
| IN e8   | IN 0      | Load register A with data from port e8                                          |
| OUT e8  | OUT 255   | Send data from register A to port e8                                            |
| XTHL    |           | Exchange data from top of stack with HL                                         |
| PCHL    |           | Fill program counter with data from HL                                          |
| SPHL    |           | Fill stack pointer with data from HL                                            |
| XCHG    |           | Exchange DE pair with HL pair                                                   |

## Arithmetic Logic Unit Operations

Instructions which act upon the single precision accumulator to perform arithmetic and logic operations are

|        |         |                                                                                                       |
|--------|---------|-------------------------------------------------------------------------------------------------------|
| ADD e3 | ADD B   | Add register given by e3 to accumulator without carry (e3 must produce one of A, B, C, D, E, H, or L) |
| ADC e3 | ADC L   | Add register to A with carry, e3 as above                                                             |
| SUB e3 | SUB H   | Subtract reg e3 from A without carry, e3 is defined as above                                          |
| SBB e3 | SBB 2   | Subtract register e3 from A with carry, e3 defined as above                                           |
| ANA e3 | ANA 1+1 | Logical "and" reg with A, e3 as above                                                                 |
| XRA e3 | XRA A   | "Exclusive or" with A, e3 as above                                                                    |
| ORA e3 | ORA B   | Logical "or" with A, e3 defined as above                                                              |
| CMP e3 | CMP H   | Compare register with A, e3 as above                                                                  |
| DAA    |         | Decimal adjust register A based upon last arithmetic logic unit operation                             |
| CMA    |         | Complement the bits in register A                                                                     |

|        |       |                                                                                   |
|--------|-------|-----------------------------------------------------------------------------------|
| STC    |       | Set the carry flag to 1                                                           |
| CMC    |       | Complement the carry flag                                                         |
| RLC    |       | Rotate bits left, (re)set carry as a side effect (high order A bit becomes carry) |
| RRC    |       | Rotate bits right, (re)set carry as side effect (low order A bit becomes carry)   |
| RAL    |       | Rotate carry/A register to left (carry is involved in the rotate)                 |
| RAR    |       | Rotate carry/A register to right (carry is involved in the rotate)                |
| DAD e3 | DAD B | Double precision add register pair e3 to HL (e3 must produce B, D, H, or SP)      |

## Control Instructions

The four remaining instructions are categorized as control instructions, and are listed below

|     |                              |
|-----|------------------------------|
| HLT | Halt the 8080 processor      |
| DI  | Disable the interrupt system |
| EI  | Enable the interrupt system  |
| NOP | No operation                 |

## Error Messages

When errors occur within the assembly language program, they are listed as single character flags in the leftmost position of the source listing. The line in error is also echoed at the console so that the source listing need not be examined to determine if errors are present. The error codes are

|   |                                                                                                                               |
|---|-------------------------------------------------------------------------------------------------------------------------------|
| D | Data error: element in data statement cannot be placed in the specified data area                                             |
| E | Expression error: expression is ill-formed and cannot be computed at assembly time                                            |
| L | Label error: label cannot appear in this context (may be duplicate label)                                                     |
| N | Not implemented: features which will appear in future ASM versions (e.g., macros) are recognized, but flagged in this version |

- O      Overflow: expression is too complicated (i.e., too many pending operators) to compute; simplify it
- P      Phase error: label does not have the same value on two subsequent passes through the program
- R      Register error: the value specified as a register is not compatible with the operation code
- V      Value error: operand encountered in expression is improperly formed

Several error messages are printed which are due to terminal error conditions

|                                    |                                                                                                      |
|------------------------------------|------------------------------------------------------------------------------------------------------|
| <b>NO SOURCE FILE<br/>PRESENT</b>  | The file specified in the ASM command does not exist on disk                                         |
| <b>NO DIRECTORY SPACE</b>          | The disk directory is full; erase files which are not needed, and retry                              |
| <b>SOURCE FILE NAME<br/>ERROR</b>  | Improperly formed ASM file name (e.g., it is specified with "?" fields)                              |
| <b>SOURCE FILE READ<br/>ERROR</b>  | Source file cannot be read properly by the assembler, execute a TYPE to determine the point of error |
| <b>OUTPUT FILE WRITE<br/>ERROR</b> | Output files cannot be written properly, most likely cause is a full disk; erase and retry           |
| <b>CANNOT CLOSE FILE</b>           | Output file cannot be closed, check to see if disk is write protected                                |

# A Sample Session

The following session shows interaction with the assembler and debugger in the development of a simple assembly language program.

ASM SORT Assemble SORT. ASM

CP/M ASSEMBLER - VER 1.0

015C next free address

003H USE FACTOR % of table used 00 to FF (hexadecimal)

END OF ASSEMBLY

DIR SORT.\*

SORT ASM source file

SORT BAK backup from last edit

SORT PRN print file (contains tab characters)

SORT HEX machine code file

A>TYPE SORT.PRN

Source line

|                       |                          |                                                      |
|-----------------------|--------------------------|------------------------------------------------------|
| machine code location |                          | SORT PROGRAM IN CP/M ASSEMBLY LANGUAGE               |
| 0100                  | ← generated machine code | START AT THE BEGINNING OF THE TRANSIENT PROGRAM AREA |
|                       |                          | ORG 100H                                             |
| 0100 214601           | ← SORT.                  | LXI H, SW ;ADDRESS SWITCH TOGGLE                     |
| 0103 3601             |                          | MVI M, 1 ;SET TO 1 FOR FIRST ITERATION               |
| 0105 214701           |                          | LXI H, I ;ADDRESS INDEX                              |
| 0108 3600             |                          | MVI M, 0 ;I = 0                                      |
|                       |                          |                                                      |
|                       |                          | COMPARE I WITH ARRAY SIZE                            |
| 010A 7E               | COMP.                    | MOV A, M ;A REGISTER = I                             |
| 010B FE09             |                          | CPI M-1 ;CY SET IF I < (N-1)                         |
| 010D D21901           |                          | JNC CONT ;CONTINUE IF I <= (N-2)                     |
|                       |                          |                                                      |
|                       |                          | END OF ONE PASS THROUGH DATA                         |
| 0110 214601           |                          | LXI H, SW ;CHECK FOR ZERO SWITCHES                   |
| 0113 7E07C20001       |                          | MOV A, M! ORA A! JNZ SORT ;END OF SORT IF SW=0       |
|                       |                          |                                                      |
| 0110 FF               |                          | RST 7 ;GO TO THE DEBUGGER INSTEAD OF RET             |
|                       | truncated                | CONTINUE THIS PASS                                   |
| 0119 5F16002148       | CONT.                    | ADDRESSING I, SO LOAD AV(I) INTO REGISTERS           |
| 0121 4E792346         |                          | MOV E, A! MVI D, 0! LXI H, AV! DAD D! DAD D          |
|                       |                          | MOV C, M! MOV A, C! INX H! MOV B, M                  |
|                       |                          | LOW ORDER BYTE IN A AND C, HIGH ORDER BYTE IN B      |
|                       |                          |                                                      |
| 0125 23               |                          | MOV H AND L TO ADDRESS AV(I+1)                       |
|                       |                          | INX H                                                |
|                       |                          |                                                      |
| 0126 965770239E       |                          | COMPARE VALUE WITH REGS CONTAINING AV(I)             |
|                       |                          | SUB M! MOV D, A! MOV A, B! INX H! SBB M ;SUBTRACT    |
|                       |                          |                                                      |
| 012B DA3F01           |                          | BORROW SET IF AV(I+1) > AV(I)                        |
|                       |                          | JC INCI ;SKIP IF IN PROPER ORDER                     |
|                       |                          |                                                      |
| 012E B2CA3F01         |                          | CHECK FOR EQUAL VALUES                               |
| 0132 56702B5E         |                          | ORA D! JZ INCI ;SKIP IF AV(I) = AV(I+1)              |
| 0136 712B722B73       |                          | MOV D, M! MOV M, B! DCX H! MOV E, M                  |
|                       |                          | MOV M, C! DCX H! MOV M, D! DCX H! MOV M, E           |
|                       |                          |                                                      |
|                       |                          | INCREMENT SWITCH COUNT                               |
| 013B 21460134         |                          | LXI H, SW! INR M                                     |

```

INCREMENT I
013F 21470134C3INCI, LXI H,I! IHR MI JMP COMP

DATA DEFINITION SECTION
0146 00 SW, DB 0, RESERVE SPACE FOR SWITCH COUNT
0147 I, DS 1, SPACE FOR INDEX
0148 050064001EAV, DW 5, 100, 30, 50, 20, 7, 1000, 300, 100, -32767
000A = N EQU (*-AV)/2, COMPUTE N INSTEAD OF PRE
015C ← equate value END
A>TYPE SORT HEX

```

```

10010000214601360121470136007EFE09D2190140
100110002146017EB7C20001FF5F16002148011903
10012000194E79234623965778239EDA3F0182CAA7
100130003F0156702B5E712B722B732146013421C7
07014000470134C30A01006E
10014000050064001E00320014000700E0032C01B0
0401500064000100BE
0000000000
A>DDT SORT HEX start debug run

```

machine code in HEX format

```

16K DDT VER 1.0
NEXT PC
015C 0000 default address (no address on END statement)
-XP

```

P=0000 100 change PC to 100

-UFFFF untrace for 65535 steps

```

C0Z0M0E010 A=00 B=0000 D=0000 H=0000 S=0100 P=0100 LXI H,0146*0100
-T10 trace 1016 steps

```

```

C0Z0M0E010 A=01 B=0000 D=0000 H=0146 S=0100 P=0100 LXI H,0146
C0Z0M0E010 A=01 B=0000 D=0000 H=0146 S=0100 P=0103 MVI M,01
C0Z0M0E010 A=01 B=0000 D=0000 H=0146 S=0100 P=0105 LXI H,0147
C0Z0M0E010 A=01 B=0000 D=0000 H=0147 S=0100 P=0108 MVI M,00
C0Z0M0E010 A=01 B=0000 D=0000 H=0147 S=0100 P=010A MOV A,M
C0Z0M0E010 A=00 B=0000 D=0000 H=0147 S=0100 P=010B CPI 09
C1Z0M1E010 A=00 B=0000 D=0000 H=0147 S=0100 P=010D JMC 0119
C1Z0M1E010 A=00 B=0000 D=0000 H=0147 S=0100 P=0110 LXI H,0146
C1Z0M1E010 A=00 B=0000 D=0000 H=0146 S=0100 P=0113 MOV A,M
C1Z0M1E010 A=01 B=0000 D=0000 H=0146 S=0100 P=0114 ORA A
C0Z0M0E010 A=01 B=0000 D=0000 H=0146 S=0100 P=0115 JNZ 0100
C0Z0M0E010 A=01 B=0000 D=0000 H=0146 S=0100 P=0100 LXI H,0146
C0Z0M0E010 A=01 B=0000 D=0000 H=0146 S=0100 P=0103 MVI M,01
C0Z0M0E010 A=01 B=0000 D=0000 H=0146 S=0100 P=0105 LXI H,0147
C0Z0M0E010 A=01 B=0000 D=0000 H=0147 S=0100 P=0108 MVI M,00
C0Z0M0E010 A=01 B=0000 D=0000 H=0147 S=0100 P=010A MOV A,M*010B
-A10D

```

```

010D JC 119 change to a jump on carry
0110

```

-XP

P=010B 100 reset program counter back to beginning of program

-T10 trace execution for 10H steps

```

C0Z0M0E010 A=00 B=0000 D=0000 H=0147 S=0100 P=0100 LXI H,0146
C0Z0M0E010 A=00 B=0000 D=0000 H=0146 S=0100 P=0103 MVI M,01
C0Z0M0E010 A=00 B=0000 D=0000 H=0146 S=0100 P=0105 LXI H,0147
C0Z0M0E010 A=00 B=0000 D=0000 H=0147 S=0100 P=0108 MVI M,00
C0Z0M0E010 A=00 B=0000 D=0000 H=0147 S=0100 P=010A MOV A,M
C0Z0M0E010 A=00 B=0000 D=0000 H=0147 S=0100 P=010B CPI 09
C1Z0M1E010 A=00 B=0000 D=0000 H=0147 S=0100 P=010D JMC 0119
C1Z0M1E010 A=00 B=0000 D=0000 H=0147 S=0100 P=0119 MOV A,A
C1Z0M1E010 A=00 B=0000 D=0000 H=0147 S=0100 P=011A MVI D,00
C1Z0M1E010 A=00 B=0000 D=0000 H=0147 S=0100 P=011C LXI H,0148
C1Z0M1E010 A=00 B=0000 D=0000 H=0148 S=0100 P=011F DAD D
C0Z0M1E010 A=00 B=0000 D=0000 H=0148 S=0100 P=0120 DAD D

```

stopped at 10BH

altered instruction

```

C020M1E010 A=00 B=0000 D=0000 H=0140 S=0100 P=0121 MOV C,M
C020M1E010 A=00 B=0000 D=0000 H=0140 S=0100 P=0122 MOV A,C
C020M1E010 A=05 B=0005 D=0000 H=0140 S=0100 P=0123 INX H
C020M1E010 A=05 B=0005 D=0000 H=0149 S=0100 P=0124 MOV B,H*0125
-L100

```

Automatic  
breakpoint

```

0100 LXI H,0146
0103 MVI M,01
0105 LXI H,0147
0108 MVI M,00
010A MOV A,M
010B CPI 09
010D JC 0119
0110 LXI H,0146
0113 MOV A,M
0114 ORA A
0115 JNZ 0100
-L

```

list some code  
from 100H

```

0116 RST 07
0119 MOV E,A
011A MVI D,00
011C LXI H,0148

```

list more

- abort list with rubout

-G,110 start program from current PC (0125H) and run in real time to 11BH

\*0127 stopped with an external interrupt 7 from front panel (program was looping indefinitely)  
-T4 look at looping program in trade mode

```

C020M0E010 A=30 B=0064 D=0006 H=0156 S=0100 P=0127 MOV D,A
C020M0E010 A=30 B=0064 D=3006 H=0156 S=0100 P=0128 MOV A,B
C020M0E010 A=00 B=0064 D=3006 H=0156 S=0100 P=0129 INX H
C020M0E010 A=00 B=0064 D=3006 H=0157 S=0100 P=012A SBB M*012B
-D140

```

data is sorted, but program doesn't stop

```

0140 05 00 07 00 14 00 1E 00
0150 32 00 64 00 64 00 2C 01 E0 03 01 00 00 00 00 00 2 D D
0160 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00

```

-G0 return to CP/M

DDT SDRT,HEX reload the memory image

```

16K DDT VER 1.0
NEXT PC
015C 0000
-XP

```

P=0000 100 Set PC to beginning of program

```

-L100
0100 JMC 0119
0110 LXI H,0146

```

list bad opcode

- abort list with rubout

-A100 assemble new opcode

```

0100 JC 119

```

```

0110

```

-L100 list starting section of program

```

0100 LXI H,0146
0103 MVI M,01
0105 LXI H,0147
0108 MVI M,00

```

- abort list with rubout

-A103 change "switch" initialization to 00

0103 MVI M, 0

0105

- ^C return to CP/M with ctrl-c (G0 works as well)

SAVE 1 SORT.COM save 1 page (256 bytes, from 100H to 1FFMH) on disk in case we have to reload later

A>DDT SORT.COM restart DDT with saved memory image

16K DDT VER 1.0

NEXT PC

0200 0100 "COM" file always starts with address 100H

- G run the program from PC=100H

\*0110 programmed stop (RST 7) encountered

- D140

0140 05 00 07 00 14 00 1E 00 ..... data properly sorted  
0150 32 00 64 00 64 00 2C 01 E8 03 01 00 00 00 00 00 2 D D .....  
0160 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 .....  
0170 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 .....

- G0 return to CP/M

ED SORT.ASM make changes to original program

ctrl-Z

\*M.0^Z0TT find next ".0"

MVI M, 0 ; I = 0

\*- up one line in text

LXI H, 1 ; ADDRESS INDEX

\*- up another line

MVI M, 1 ; SET TO 1 FOR FIRST ITERATION

\*KT kill line and type next line

LXI H, 1 ; ADDRESS INDEX

\*I insert new line

MVI M, 0 ; ZERO SW

\*T

LXI H, 1 ; ADDRESS INDEX

\*NJNC 00T

JNC \*T

CONT ; CONTINUE IF I <= (M-2)

\*-2D1C 00LT

JC CONT ; CONTINUE IF I <= (M-2)

\*E

source from disk A

hex to disk A

ASM SORT.AAZ skip pm file

CP/M ASSEMBLER - VER 1.0

015C next address to assemble

003H USE FACTOR

END OF ASSEMBLY

DDT SORT.HEX test program changes

16K DDT VER 1.0

NEXT PC

015C 0000

- G100

\*0110

- D140

0140 05 00 07 00 14 00 1E 00 ..... data sorted  
0150 32 00 64 00 64 00 2C 01 E8 03 01 00 00 00 00 00 2 D D .....  
0160 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 .....

- abort with rubout

- G0 return to CP/M - program checks OK.





## **CHAPTER 5**

### **CP/M Dynamic Debugging Tool**

- **Introduction**
- **DDT Commands**
- **The A (Assemble) Command**
- **The D (Display) Command**
- **The F (Fill) Command**
- **The G (Go) Command**
- **The I (Input) Command**
- **The L (List) Command**
- **The M (Move) Command**
- **The R (Read) Command**
- **The S (Set) Command**
- **The T (Trace) Command**
- **The U (Untrace) Command**
- **The X (Examine) Command**
- **Implementation Notes**
- **Sample Session**



# Introduction

The DDT program allows dynamic interactive testing and debugging of programs generated in the CP/M environment. The debugger is initiated by typing one of the following commands at the CP/M Console Command level

```
DDT
DDT filename.HEX
DDT filename.COM
```

where "filename" is the name of the program to be loaded and tested. In both cases, the DDT program is brought into main memory in the place of the Console Command Processor (refer to the CP/M Interface Guide for standard memory organization), and thus resides directly below the Basic Disk Operating System portion of CP/M. The BDOS starting address, which is located in the address field of the JMP instruction at location 5H, is altered to reflect the reduced Transient Program Area size.

The second and third forms of the DDT command shown above perform the same actions as the first, except there is a subsequent automatic load of the specified HEX or COM file. The action is identical to the sequence of commands

```
DDT
Ifilename.HEX or Ifilename.COM
R
```

where the I and R commands set up and read the specified program to test. (See the explanation of the I and R commands below for exact details.)

Upon initiation, DDT prints a sign-on message in the format

```
nnK DDT-s VER m.m
```

where nn is the memory size (which must match the CP/M system being used), s is the hardware system which is assumed, corresponding to the codes

|   |                                   |
|---|-----------------------------------|
| D | Digital Research standard version |
| M | MDS version                       |
| I | IMSAI standard version            |
| O | Omron systems                     |
| S | Digital Systems standard version  |

and m.m is the revision number.

Following the sign on message, DDT prompts the operator with the character “\_” and waits for input commands from the console. The operator can type any of several single character commands, terminated by a carriage return to execute the command. Each line of input can be line-edited using the standard CP/M controls

|           |                                             |
|-----------|---------------------------------------------|
| rubout    | remove the last character typed             |
| Control-X | remove the entire line, ready for re-typing |
| Control-C | system reboot                               |

Any command can be up to 32 characters in length (an automatic carriage return is inserted as the 33rd character), where the first character determines the command type

|   |                                                  |
|---|--------------------------------------------------|
| A | enter assembly language mnemonics with operands  |
| D | display memory in hexadecimal and ASCII          |
| F | fill memory with constant data                   |
| G | begin execution with optional breakpoints        |
| I | set up a standard input file control block       |
| L | list memory using assembler mnemonics            |
| M | move a memory segment from source to destination |
| R | read program for subsequent testing              |
| S | substitute memory values                         |
| T | trace program execution                          |
| U | untraced program monitoring                      |
| X | examine and optionally alter the CPU state       |

The command character, in some cases, is followed by zero, one, two, or three hexadecimal values which are separated by commas or single blank characters. All DDT numeric output is in hexadecimal form. In all cases, the commands are not executed until the carriage return is typed at the end of the command.

At any point in the debug run, the operator can stop execution of DDT using either a Control-C or G0 (jmp to location 0000H), and save the current memory image using a SAVE command of the form

## SAVE n filename.COM

where n is the number of pages (256 byte blocks) to be saved on disk. The number of blocks can be determined by taking the high order byte of the top load address and converting this number to decimal. For example, if the highest address in the Transient Program Area is 1234H then the number of pages is 12H, or 18 in decimal. Thus the operator could type a Control-C during the debug run, returning to the Console Processor level, followed by

## SAVE 18 X.COM

The memory image is saved as X.COM on the diskette, and can be directly executed by simply typing the name X. If further testing is required, the memory image can be recalled by typing

## DDT X.COM

which reloads the previously saved program from location 100H through page 18 (12FFH). The machine state is not a part of the COM file, and thus the program must be restarted from the beginning in order to properly test it.

# DDT Commands

The individual commands are given below in some detail. In each case, the operator must wait for the prompt character (-) before entering the command. If control is passed to a program under test, and the program has not reached a breakpoint, control can be returned to DDT by executing a RST 7 from the front panel (note that the rubout key should be used instead if the program is executing a T or U command). In the explanation of each command, the command letter is shown in some cases with numbers separated by commas, where the numbers are represented by lower case letters. These numbers are always assumed to be in a hexadecimal radix, and from one to four digits in length (longer numbers will be automatically truncated on the right).

Many of the commands operate upon a "CPU state" which corresponds to the program under test. The CPU state holds the registers of the program being debugged, and initially contains zeroes for all registers and flags except for the program counter (P) and stack pointer (S), which default to 100H. The program counter is subsequently set to the starting address given in the last record of a HEX file if a file of this form is loaded (see the I and R commands).

## The A (Assemble) Command

DDT allows inline assembly language to be inserted into the current memory image using the A command which takes the form

As

where s is the hexadecimal starting address for the inline assembly. DDT prompts the console with the address of the next instruction to fill, and reads the console, looking for assembly language mnemonics (see the Intel 8080 Assembly Language Reference Card for a list of mnemonics), followed by register references and operands in absolute hexadecimal form. Each successive load address is printed before reading the console. The A command terminates when the first empty line is input from the console.

Upon completion of assembly language input, the operator can review the memory segment using the DDT disassembler. (See the L command.)

Note that the assembler/disassembler portion of DDT can be overlayed by the transient program being tested, in which case the DDT program responds with an error condition when the A and L commands are used.

## The D (Display) Command

The D command allows the operator to view the contents of memory in hexadecimal and ASCII formats. The forms are

D  
Ds  
Ds,f

In the first case, memory is displayed from the current display address (initially 100H), and continues for 16 display lines. Each display line takes the form shown below

aaaa bb bb bb bb bb bb bb bb bb bb bb bb bb bb ccccccccccccccc

where aaaa is the display address in hexadecimal, and bb represents data present in memory starting at aaaa. The ASCII characters starting at aaaa are given to the right (represented by the sequence of c's), where non-graphic characters are printed as a period (.) symbol. Note that both upper and lower case alphabets are displayed, and thus will appear as upper case symbols on a console device that supports only upper case. Each display line gives the values of 16 bytes of data, except that the first line displayed is truncated so that the next line begins at an address which is the multiple of 16.

The second form of the D command shown above is similar to the first, except that the display address is first set to address s. The third form causes the display to continue from address s through address f. In all cases, the display address is set to the first address not displayed in this command, so that a continuing display can be accomplished by issuing successive D commands with no explicit addresses.

Excessively long displays can be aborted by pushing the rubout key.

## The F (Fill) Command

The F command takes the form

Fs,f,c

where s is the starting address, f is the final address, and c is a hexadecimal byte constant. The effect is as follows: DDT stores the constant c at address s, increments the value of s and tests against f. If s exceeds f then the operation terminates, otherwise the operation is repeated. Thus, the fill command can be used to set a memory block to a specific constant value.

## The G (Go) Command

Program execution is started using the G command, with up to two optional breakpoint addresses. The G command takes one of the forms

G  
Gs  
Gs,b  
Gs,b,c  
G,b  
G,b,c

The first form starts execution of the program under test at the current value of the program counter in the current machine state, with no breakpoints set (the only way to regain control in DDT is through a RST 7 execution). The current program counter can be viewed by typing an X or XP command. The second form is similar to the first except that the program counter in the current machine state is set to address s before execution begins. The third form is the same as the second, except that program execution stops when address b is encountered (b must be in the area of the program under test). The instruction at location b is not executed when the breakpoint is encountered. The fourth form is identical to the third, except that two breakpoints are specified, one at b and the other at c. Encountering either breakpoint causes execution to stop, and both breakpoints are subsequently

cleared. The last two forms take the program counter from the current machine state, and set one and two breakpoints, respectively.

Execution continues from the starting address in real-time to the next breakpoint. That is, there is no intervention between the starting address and the break address by DDT. Thus, if the program under test does not reach a breakpoint, control cannot return to DDT without executing a RST 7 instruction. Upon encountering a breakpoint, DDT stops execution and types

\*d

where d is the stop address. The machine state can be examined at this point using the X (Examine) command. The operator must specify breakpoints which differ from the program counter address at the beginning of the G command. Thus, if the current program counter is 1234H, then the commands

G,1234

and

G400,400

both produce an immediate breakpoint, without executing any instructions whatsoever.

## The I (Input) Command

The I command allows the operator to insert a file name into the default file control block at 5CH (the file control block created by CP/M for transient programs is placed at this location; see the CP/M Interface Guide). The default FCB can be used by the program under test as if it had been passed by the CP/M Console Processor. Note that this file name is also used by DDT for reading additional HEX and COM files. The form of the I command is

Ifilename

or

Ifilename.filetype

If the second form is used, and the filetype is either HEX or COM, then subsequent R commands can be used to read the pure binary or hex format machine code (see the R command for further details).



## The L (List) Command

The L command is used to list assembly language mnemonics in a particular program region. The forms are

L  
Ls  
Ls,f

The first command lists twelve lines of disassembled machine code from the current list address. The second form sets the list address to s, and then lists twelve lines of code. The last form lists disassembled code from s through address f. In all three cases, the list address is set to the next unlisted location in preparation for a subsequent L command. Upon encountering an execution breakpoint, the list address is set to the current value of the program counter (see the G and T commands). Again, long typeouts can be aborted using the rubout key during the list process.

## The M (Move) Command

The M command allows block movement of program or data areas from one location to another in memory. The form is

Ms,f,d

where s is the start address of the move, f is the final address of the move, and d is the destination address. Data is first moved from s to d, and both addresses are incremented. If s exceeds f then the move operation stops, otherwise the move operation is repeated.

## The R (Read) Command

The R command is used in conjunction with the I command to read COM and HEX files from the diskette into the transient program area in preparation for the debut run. The forms are

R  
Rb

where b is an optional bias address which is added to each program or data address as it is loaded. The load operation must not overwrite any of the system parameters from 000H through 0FFH (i.e., the first page of memory). If b is omitted, then b = 0000 is assumed. The R command requires a previous I command, specifying the name of a HEX or COM file. The load address for

each record is obtained from each individual HEX record, while an assumed load address of 100H is taken for COM files. Note that any number of R commands can be issued following the I command to re-read the program under test, assuming the tested program does not destroy the default area at 5CH. Further, any file specified with the filetype "COM" is assumed to contain machine code in pure binary form (created with the LOAD or SAVE command), and all others are assumed to contain machine code in Intel hex format (produced, for example, with the ASM command).

Recall that the command

DDT filename.filetype

which initiates the DDT program is equivalent to the commands

```
DDT
-Ifilename.filetype
-R
```

Whenever the R command is issued, DDT responds with either the error indicator "?" (file cannot be opened, or a checksum error occurred in a HEX file), or with a load message taking the form

```
NEXT PC
nnnn pppp
```

where nnnn is the next address following the loaded program, and pppp is the assumed program counter (100H for COM files, or taken from the last record if a HEX file is specified).

## The S (Set) Command

The S command allows memory locations to be examined and optionally altered. The form of the command is

```
Ss
```

where s is the hexadecimal starting address for examination and alteration of memory. DDT responds with a numeric prompt, giving the memory location, along with the data currently held in the memory location. If the operator types a carriage return, then the data is not altered. If a byte value is typed, then the value is stored at the prompted address. In either case, DDT continues to prompt with successive addresses and values until either a period (.) is typed by the operator, or an invalid input value is detected.

## The T (Trace) Command

The T command allows selective tracing of program execution for 1 to 65535 program steps. The forms are

T  
Tn

In the first case, the CPU state is displayed, and the next program step is executed. The program terminates immediately, with the termination address displayed as

\*hhhh

where hhhh is the next address to execute. The display address (used in the D command) is set to the value of H and L, and the list address (used in the L command) is set to hhhh. The CPU state at program termination can then be examined using the X command.

The second form of the T command is similar to the first, except that execution is traced for n steps (n is a hexadecimal value) before a program breakpoint occurs. A breakpoint can be forced in the trace mode by typing a rubout character. The CPU state is displayed before each program step is taken in trace mode. The format of the display is the same as described in the X command.

Note that program tracing is discontinued at the interface to CP/M, and resumes after return from CP/M to the program under test. Thus, CP/M functions which access I/O devices, such as the diskette drive, run in real-time, avoiding I/O timing problems. Programs running in trace mode execute approximately 500 times slower than real time since DDT gets control after each user instruction is executed. Interrupt processing routines can be traced, but it must be noted that commands which use the breakpoint facility (G, T, and U) accomplish the break using a RST 7 instruction, which means that the tested program cannot use this interrupt location. Further, the trace mode always runs the tested program with interrupts enabled, which may cause problems if asynchronous interrupts are received during tracing.

Note also that the operator should use the rubout key to get control back to DDT during trace, rather than executing a RST 7, in order to ensure that the trace for the current instruction is completed before interruption.

## The U (Untrace) Command

The U command is identical to the T command except that intermediate program steps are not displayed. The untrace mode allows from 1 to 65535 (0FFFFH) steps to be executed in monitored mode, and is used principally to retain control of an executing program while it reaches steady state conditions. All conditions of the T command apply to the U command.

## The X (Examine) Command

The X command allows selective display and alteration of the current CPU state for the program under test. The forms are

X  
Xr

where r is one of the 8080 CPU registers

|   |                  |          |
|---|------------------|----------|
| C | Carry Flag       | (0/1)    |
| Z | Zero Flag        | (0/1)    |
| M | Minus Flag       | (0/1)    |
| E | Even Parity Flag | (0/1)    |
| I | Interdigit Carry | (0/1)    |
| A | Accumulator      | (0-FF)   |
| B | BC register pair | (0-FFFF) |
| D | DE register pair | (0-FFFF) |
| H | HL register pair | (0-FFFF) |
| S | Stack Pointer    | (0-FFFF) |
| P | Program Counter  | (0-FFFF) |

In the first case, the CPU register state is displayed in the format

CfZfMfEfIf A=bb B=dddd D=dddd H=dddd S=dddd P=dddd inst

where f is a 0 or 1 flag value, bb is a byte value, and dddd is a double byte quantity corresponding to the register pair. The "inst" field contains the disassembled instruction which occurs at the location addressed by the CPU state's program counter.

The second form allows display and optional alteration of register values, where r is one of the registers given above (C, Z, M, E, I, A, B, D, H, S, or P). In each case, the flag or register value is first displayed at the console. The DDT program then accepts input from the console. If a carriage return is typed, then the flag or register value is not altered. If a value in the proper range is typed, then the flag or register value is altered. Note that BC, DE,

and HL are displayed as register pairs. Thus, the operator types the entire register pair when B, C, or the BC pair is altered.

## Implementation Notes

The organization of DDT allows certain non-essential portions to be overlayed in order to gain a larger transient program area for debugging large programs. The DDT program consists of two parts: the DDT nucleus and the assembler/disassembler module. The DDT nucleus is loaded over the Console Command Processor, and, although loaded with the DDT nucleus, the assembler/disassembler is overlayable unless used to assemble or disassemble.

In particular, the BDOS address at location 6H (address field of the JMP instruction at location 5H) is modified by DDT to address the base location of the DDT nucleus which, in turn, contains a JMP instruction to the BDOS. Thus, programs which use this address field to size memory see the logical end of memory at the base of the DDT nucleus rather than the base of the BDOS.

The assembler/disassembler module resides directly below the DDT nucleus in the transient program area. If the A, L, T, or X commands are used during the debugging process then the DDT program again alters the address field at 6H to include this module, thus further reducing the logical end of memory. If a program loads beyond the beginning of the assembler/disassembler module, the A and L commands are lost (their use produces a "?" in response), and the trace and display (T and X) commands list the "inst" field of the display in hexadecimal, rather than as a decoded instruction.

## Sample Session

The following example shows an edit, assemble, and debug for a simple program which reads a set of data values and determines the largest value in the set. The largest value is taken from the vector, and stored into "LARGE" at the termination of the program

### ED SCAN.ASM

```

*1
11  ORG 11 100H  ; L: START OF TRANSIENT AREA
    MVI B,LEN ; LENGTH OF VECTOR TO SCAN
    MVI C,0    ; LARGEST-EST VALUE SO FAR
LOOP--P.O.O.L LXI H,VECT ;BASE OF VECTOR
    MOV A,M    ;GET VALUE
    SUB C      ;LARGEST VALUE IN C?
    JNC NFOUND ;JUMP IF LARGEST VALUE NOT FOUND
;characters NEW LARGEST VALUE, STORE IT TO C
    MOV C,A

```

Annotations in the original image:

- tab character points to the space between 11 and ORG
- rubout points to the space between 100H and ;
- rubout echo points to the space between ; and L:
- rubout points to the space between L: and START
- rubout points to the space between START and OF
- rubout points to the space between OF and TRANSIENT
- rubout points to the space between TRANSIENT and AREA
- rubout points to the space between AREA and ;
- rubout points to the space between ; and LENGTH
- rubout points to the space between LENGTH and OF
- rubout points to the space between OF and VECTOR
- rubout points to the space between VECTOR and TO
- rubout points to the space between TO and SCAN
- rubout points to the space between SCAN and ;
- rubout points to the space between ; and LARGEST-EST
- rubout points to the space between LARGEST-EST and VALUE
- rubout points to the space between VALUE and SO
- rubout points to the space between SO and FAR
- rubout points to the space between FAR and ;
- rubout points to the space between ; and BASE
- rubout points to the space between BASE and OF
- rubout points to the space between OF and VECTOR
- rubout points to the space between VECTOR and ;
- rubout points to the space between ; and GET
- rubout points to the space between GET and VALUE
- rubout points to the space between VALUE and ;
- rubout points to the space between ; and LARGEST
- rubout points to the space between LARGEST and VALUE
- rubout points to the space between VALUE and IN
- rubout points to the space between IN and C?
- rubout points to the space between C? and ;
- rubout points to the space between ; and JUMP
- rubout points to the space between JUMP and IF
- rubout points to the space between IF and LARGEST
- rubout points to the space between LARGEST and VALUE
- rubout points to the space between VALUE and NOT
- rubout points to the space between NOT and FOUND
- rubout points to the space between FOUND and ;
- rubout points to the space between ; and NEW
- rubout points to the space between NEW and LARGEST
- rubout points to the space between LARGEST and VALUE
- rubout points to the space between VALUE and ,
- rubout points to the space between , and STORE
- rubout points to the space between STORE and IT
- rubout points to the space between IT and TO
- rubout points to the space between TO and C
- rubout points to the space between C and ;
- rubout points to the space between ; and MOV
- rubout points to the space between MOV and C
- rubout points to the space between C and A
- rubout points to the space between A and ;

```

NFOUND: INX      H           ;TO NEXT ELEMENT
        DCR      B           ;MORE TO SCAN?
        JNZ      LOOP       ;FOR ANOTHER

;
; END OF SCAN, STORE C
        MOV      A,C         ;GET LARGEST VALUE
        STA      LARGE
        JMP      0           ;REBOOT

;
; TEST DATA
VECT:   DB      2,0,4,3,5,6,1,5
LEN     EQU     $-VECT       ;LENGTH
LARGE:  DS      1           ;LARGEST VALUE ON EXIT
END

```

Create Source  
Program — underlined  
characters typed  
by programmer.

```

TZ=00P
ORG     100H           ;START OF TRANSIENT AREA
MVI     B,LEN          ;LENGTH OF VECTOR TO SCAN
MVI     C,0            ;LARGEST VALUE SO FAR
LXI     H,VECT         ;BASE OF VECTOR
LOOP:   MOV      A,M     ;GET VALUE
        SUB      C       ;LARGER VALUE IN C?
        JNC      NFOUND  ;JUMP IF LARGER VALUE NOT FOUND
        NEW LARGEST VALUE, STORE IT TO C
        MOV      C,A
NFOUND: INX      H       ;TO NEXT ELEMENT
        DCR      B       ;MORE TO SCAN?
        JNZ      LOOP    ;FOR ANOTHER
        END OF SCAN, STORE C
        MOV      A,C     ;GET LARGEST VALUE
        STA      LARGE
        JMP      0       ;REBOOT

;
; TEST DATA
VECT:   DB      2,0,4,3,5,6,1,5
LEN     EQU     $-VECT   ;LENGTH
LARGE:  DS      1       ;LARGEST VALUE ON EXIT
END

```

\*E ← End of Edit

#### ASM SCAN

Start Assembler

CP/M ASSEMBLER - VER 1.0

0122

002H USE FACTOR

END OF ASSEMBLY Assembly Complete — Look at Program Listing

#### TYPE SCAN.PRN

| Code Address    | Machine Code | Source Program                             |
|-----------------|--------------|--------------------------------------------|
| 0100            |              | ORG 100H ;START OF TRANSIENT AREA          |
| 0100 0600       |              | MVI B,LEN ;LENGTH OF VECTOR TO SCAN        |
| 0102 0E00       |              | MVI C,0 ;LARGEST VALUE SO FAR              |
| 0104 211901     |              | LXI H,VECT ;BASE OF VECTOR                 |
| 0107 7E         | LOOP:        | MOV A,M ;GET VALUE                         |
| 0109 91         |              | SUB C ;LARGER VALUE IN C?                  |
| 0109 D20D01     |              | JNC NFOUND ;JUMP IF LARGER VALUE NOT FOUND |
|                 |              | NEW LARGEST VALUE, STORE IT TO C           |
| 010C 4F         |              | MOV C,A                                    |
| 010D 23         | NFOUND:      | INX H ;TO NEXT ELEMENT                     |
| 010E 05         |              | DCR B ;MORE TO SCAN?                       |
| 010F C20701     |              | JNZ LOOP ;FOR ANOTHER                      |
|                 |              | END OF SCAN, STORE C                       |
| 0112 79         |              | MOV A,C ;GET LARGEST VALUE                 |
| 0113 321001     |              | STA LARGE                                  |
| 0116 C30000     |              | JMP 0 ;REBOOT                              |
|                 |              | TEST DATA                                  |
| 0119 0200040305 | VECT:        | DB 2,0,4,3,5,6,1,5                         |

Code/data listing truncated →

```

0000 = ← LEM EQU $-VECT ,LENGTH
0121 Value of LARGE: DS 1 ,LARGEST VALUE ON EXIT
0122 Equate END

```

A>

DDT SCAN HEX

Start Debugger using hex format machine code

16K DDT VER 1.0

NEXT PC

0121 0000

-X

last load address + 1

C020M0E010 A=00 B=0000 D=0000 H=0000 S=0100 P=0000 OUT 7F PC=0

next instruction to execute at

-XP

Examine registers before debug run

P=0000 100

Change PC to 100

-X

Look at registers again

C020M0E010 A=00 B=0000 D=0000 H=0000 S=0100 P=0100 MVI B,00

PC changed

-L100

Next instruction to execute at PC=100

```

0100 MVI B,00
0102 MVI C,00
0104 LXI H,0119
0107 MOV A,M
0108 SUB C
0109 JNC 010D
010C MOV C,A
010D INX H
010E DCR B
010F JNZ 0107
0112 MOV A,C

```

Disassembled Machine Code at 100H  
(See Source Listing for comparison)

-L

```

0113 STA 0121
0116 JMP 0000
0119 STAX B
011A NOP
011B INR B
011C INX B
011D DCR B
011E MVI B,01
0120 DCR B
0121 LXI D,2200
0124 LXI H,0200

```

A little more machine code  
(note that Program ends at location 116 with a JMP to 0000)

-A116

enter inline assembly mode to change the JMP to 0000 into a RST 7, which will cause the program under test to return to DDT if 116H is ever executed.

0116 RST 7

0117 (single carriage return stops assembly mode)

-L113

List Code at 113H to check that RST 7 was properly inserted

```

0113 STA 0121
0116 RST 07
0117 NOP
0118 NOP
0119 STAX B
011A NOP
011B INR B
011C INX B

```

in place of JMP

-X

Look at registers

C020M0E010 A=00 B=0000 D=0000 H=0000 S=0100 P=0100 MVI B,00

-I

Execute Program for one step.

initial CPU state, before is executed

C020M0E010 A=00 B=0000 D=0000 H=0000 S=0100 P=0100 MVI B,000102

-I

Trace one step again (note 08H in B)

automatic breakpoint

C020M0E010 A=00 B=0000 D=0000 H=0000 S=0100 P=0102 MVI C,000104

-T Trace again (Register C is cleared)  
 C020M0E010 A=00 B=0000 D=0000 H=0000 S=0100 P=0104 LXI H,0119\*0107  
 -T3 Trace three steps

C020M0E010 A=00 B=0000 D=0000 H=0119 S=0100 P=0107 MOV A,M  
 C020M0E010 A=02 B=0000 D=0000 H=0119 S=0100 P=0108 SUB C  
 C020M0E011 A=02 B=0000 D=0000 H=0119 S=0100 P=0109 JNC 010D\*010D

-D119 Display memory starting at 119H.

0119 02 00 04 03 05 06 01 Program data  
 0120 05 11 00 22 21 00 02 7E EB 77 13 23 EB 00 70 01 Lower case x  
 0130 C2 27 01 C3 03 29 00 00 00 00 00 00 00 00 00  
 0140 00 00 00 00 00 00 00 00 00 00 00 00 00 00  
 0150 00 00 00 00 00 00 00 00 00 00 00 00 00 00  
 0160 00 00 00 00 00 00 00 00 00 00 00 00 00 00  
 0170 00 00 00 00 00 00 00 00 00 00 00 00 00 00  
 0180 00 00 00 00 00 00 00 00 00 00 00 00 00 00  
 0190 00 00 00 00 00 00 00 00 00 00 00 00 00 00  
 01A0 00 00 00 00 00 00 00 00 00 00 00 00 00 00  
 01B0 00 00 00 00 00 00 00 00 00 00 00 00 00 00  
 01C0 00 00 00 00 00 00 00 00 00 00 00 00 00 00

Automatic breakpoint at 10DH  
 Data is displayed in ASCII with a "0" in the position of non-graphic characters

-X Current CPU state

C020M0E011 A=02 B=0000 D=0000 H=0119 S=0100 P=010D INX H

-T5 Trace 5 steps from current CPU state

C020M0E011 A=02 B=0000 D=0000 H=0119 S=0100 P=010D INX H  
 C020M0E011 A=02 B=0000 D=0000 H=011A S=0100 P=010E DCR B  
 C020M0E011 A=02 B=0700 D=0000 H=011A S=0100 P=010F JNZ 0107 Breakpoint  
 C020M0E011 A=02 B=0700 D=0000 H=011A S=0100 P=0107 MOV A,M  
 C020M0E011 A=00 B=0700 D=0000 H=011A S=0100 P=0108 SUB C\*0109

-U5 Trace without listing intermediate states

C021M0E111 A=00 B=0700 D=0000 H=011A S=0100 P=0109 JNC 010D\*0108

-X CPU State at end of U5

C020M0E111 A=04 B=0600 D=0000 H=0110 S=0100 P=0108 SUB C

-C Run program from current PC until completion (in real-time)  
 breakpoint at 116H, caused by executing RST 7 in machine code

\*0116

-X CPU state at end of program

C021M0E111 A=00 B=0000 D=0000 H=0121 S=0100 P=0116 RST 07

-XP examine and change program counter

P=0116 100

-X

C021M0E111 A=00 B=0000 D=0000 H=0121 S=0100 P=0100 MYI B.00  
 subtext for comparison

-T10 Trace 10 (hexadecimal) steps

C021M0E111 A=00 B=0000 D=0000 H=0121 S=0100 P=0100 MYI B.00  
 C021M0E111 A=00 B=0000 D=0000 H=0121 S=0100 P=0102 MYI C.00  
 C021M0E111 A=00 B=0000 D=0000 H=0121 S=0100 P=0104 LXI H,0119  
 C021M0E111 A=00 B=0000 D=0000 H=0119 S=0100 P=0107 MOV A,M  
 C021M0E111 A=02 B=0000 D=0000 H=0119 S=0100 P=0108 SUB C

first data element current largest value  
 A/C



```

C0Z0M0E011 A=02 B=0000 D=0000 H=0119 S=0100 P=0109 JNC 010D
C0Z0M0E011 A=02 B=0000 D=0000 H=0119 S=0100 P=010D INX H
C0Z0M0E011 A=02 B=0000 D=0000 H=011A S=0100 P=010E DCR B
C0Z0M0E011 A=02 B=0700 D=0000 H=011A S=0100 P=010F JNZ 0107
C0Z0M0E011 A=02 B=0700 D=0000 H=011A S=0100 P=0107 MOV A,M
C0Z0M0E011 A=00 B=0700 D=0000 H=011A S=0100 P=0100 SUB C
C0Z1M0E111 A=00 B=0700 D=0000 H=011A S=0100 P=0109 JNC 010D
C0Z1M0E111 A=00 B=0700 D=0000 H=011A S=0100 P=010D INX H
C0Z1M0E111 A=00 B=0700 D=0000 H=011B S=0100 P=010E DCR B
C0Z0M0E111 A=00 B=0600 D=0000 H=011B S=0100 P=010F JNZ 0107
C0Z0M0E111 A=00 B=0600 D=0000 H=011B S=0100 P=0107 MOV A,M=0108

```

-A109

0109 JC 10D

010C

Insert a "hot patch" into the machine code to change the JNC to JC

Program should have moved the value from A into C since A>C. Since this code was not executed, it appears that the JNC should have been a JC instruction

-G0

Stop DDT so that a version of the patched program can be saved

SAVE 1 SCAN.COM

Program resides on first page, so save 1 page.

A>DDT SCAN.COM

Restart DDT with the saved memory image to continue testing

16K DDT VER 1.0

NEXT PC

0200 0100

-L100

List some code

```

0100 MVI B,00
0102 MVI C,00
0104 LXI H,0119
0107 MOV A,M
0100 SUB C
0109 JC 010D
010C MOV C,A
010D INX H
010E DCR B
010F JNZ 0107
0112 MOV A,C

```

Previous patch is present in X.COM

-XF

P=0100

-T10

Trace to see how patched version operates

Data is moved from A to C

```

C0Z0M0E010 A=00 B=0000 D=0000 H=0000 S=0100 P=0100 MVI B,00
C0Z0M0E010 A=00 B=0000 D=0000 H=0000 S=0100 P=0102 MVI C,00
C0Z0M0E010 A=00 B=0000 D=0000 H=0000 S=0100 P=0104 LXI H,0113
C0Z0M0E010 A=00 B=0000 D=0000 H=0119 S=0100 P=0107 MOV A,M
C0Z0M0E010 A=02 B=0000 D=0000 H=0119 S=0100 P=0108 SUB C
C0Z0M0E011 A=02 B=0000 D=0000 H=0119 S=0100 P=0109 JC 010D
C0Z0M0E011 A=02 B=0000 D=0000 H=0119 S=0100 P=010C MOV C,A
C0Z0M0E011 A=02 B=0002 D=0000 H=0119 S=0100 P=010D INX H
C0Z0M0E011 A=02 B=0002 D=0000 H=011A S=0100 P=010E DCR B
C0Z0M0E011 A=02 B=0702 D=0000 H=011A S=0100 P=010F JNZ 0107
C0Z0M0E011 A=02 B=0702 D=0000 H=011A S=0100 P=0109 JC 010D
C0Z0M0E011 A=00 B=0702 D=0000 H=011A S=0100 P=0100 SUB C
C1Z0M1E010 A=FE B=0702 D=0000 H=011A S=0100 P=0109 JC 010D
C1Z0M1E010 A=FE B=0702 D=0000 H=011A S=0100 P=010D INX H
C1Z0M1E010 A=FE B=0702 D=0000 H=011B S=0100 P=010E DCR B
C1Z0M0E111 A=FE B=0602 D=0000 H=011B S=0100 P=010F JNZ 0107*0107

```

-X

breakpoint after 16 steps

C1Z0M0E111 A=FE B=0602 D=0000 H=011B S=0100 P=0107 MOV A,M

-G.108

Run from current PC and breakpoint at 108H

•0100

-X

next data item

C1Z0M0E111 A=04 B=0602 D=0000 H=011B S=0100 P=0108 SUB C

-I

Single step for a few cycles

C1Z0M0E111 A=04 B=0602 D=0000 H=011B S=0100 P=0100 SUB C\*0109

-I

C0Z0M0E011 A=02 B=0602 D=0000 H=011B S=0100 P=0109 JC 010D\*010C

-X

C0Z0M0E011 A=02 B=0602 D=0000 H=011B S=0100 P=010C MOV C,A

-G

Run to completion

\*0116

-X

C0Z1M0E111 A=03 B=0003 D=0000 H=0121 S=0100 P=0116 RST 07

-S121

look at the value of "LARGE"

0121 03 Wrong Value!

0122 00

0123 22

0124 21

0125 00

0126 02

End of the S command

0127 7E

-L100

0100 MVI B,03  
 0102 MVI C,00  
 0104 LXI H,0119  
 0107 MOV A,M  
 0108 SUB C  
 0109 JC 010D  
 010C MOV C,A  
 010D INX H  
 010E DCR B  
 010F JNZ 0107  
 0112 MOV A,C

Review the code

-L

0113 STA 0121  
 0116 RST 07  
 0117 NOP  
 0118 NOP  
 0119 STAX B  
 011A NOP  
 011B INR B  
 011C INX B  
 011D DCR B  
 011E MVI B,01  
 0120 DCR B

-XP

P=0116 100 Reset the PC

-I Single step, and watch data values

C0Z1M0E111 A=03 B=0003 D=0000 H=0121 S=0100 P=0100 MVI B,03\*0102

-I

C0Z1M0E111 A=03 B=0003 D=0000 H=0121 S=0100 P=0102 MVI C,00\*0104

-I

C0Z1M0E111 A=03 B=0000 D=0000 H=0121 S=0100 P=0104 LXI H,0113\*0107

-I

```

                                ↖ base address of data set
0021M0E111 A=03 B=0000 D=0000 H=0119 S=0100 P=0107 MOV A,M*0100
-I
0021M0E111 A=02 B=0000 D=0000 H=0119 S=0100 P=0108 SUB C*0109
-I
0020M0E011 A=02 B=0000 D=0000 H=0119 S=0100 P=0109 JC 010D*010C
-I
0020M0E011 A=02 B=0000 D=0000 H=0119 S=0100 P=010C MOV C,A*010D
-I
0020M0E011 A=02 B=0002 D=0000 H=0119 S=0100 P=010D INX H*010E
-I
0020M0E011 A=02 B=0002 D=0000 H=011A S=0100 P=010E DCR B*010F
-I
0020M0E011 A=02 B=0702 D=0000 H=011A S=0100 P=010F JNZ 0107*0107
-I
0020M0E011 A=02 B=0702 D=0000 H=011A S=0100 P=0107 MOV A,M*0100
-I
0020M0E011 A=00 B=0702 D=0000 H=011A S=0100 P=0108 SUB C*0109
-I
0120M1E010 A=FE B=0702 D=0000 H=011A S=0100 P=0109 JC 010D*010D
-I
0120M1E010 A=FE B=0702 D=0000 H=011A S=0100 P=010D INX H*010E
-L100
0100 MVI B,00
0102 MVI C,00
0104 LXI H,0119
0107 MOV A,M
0108 SUB C ← This should have been a CMP so that register A
0109 JC 010D would not be destroyed.
010C MOV C,A
010D INX H
010E DCR B
010F JNZ 0107
0112 MOV A,C
-H188
0108 CMP C hot patch at 108H changes SUB to CMP
0109
-G0 stop DDT for SAVE
SAVE 1 SCAN.COM save memory image
H>DDT SCAN.COM Restart DDT
16K DDT VER 1.0
NEXT PC
0200 0100
-XP
P=0100

```

-L116

|      |      |    |                                                                                       |
|------|------|----|---------------------------------------------------------------------------------------|
| 0116 | RST  | 07 | } Look at code to see if it was properly loaded<br>(long timeout aborted with rubout) |
| 0117 | NOP  |    |                                                                                       |
| 0118 | NOP  |    |                                                                                       |
| 0119 | STAX | B  |                                                                                       |
| 011A | NOP  |    |                                                                                       |

- (rubout)

-G-116 Run from 100H to completion

\*0116

-XC Look at carry (accidental typo)

01

-X Look at CPU state

012100E111 A=06 B=0000 D=0000 H=0121 S=0100 P=0116 RST 07

-S121 Look at "Large" — it appears to be correct.

0121 06

0122 00

0123 22

-G0 stop DDT

ED SCAN.ASM

Re-edit the source program, and make both changes

```
*NSUB
*BLT
SUB C, C ;LARGER VALUE IN C?
*SUB C, C ;LARGER VALUE IN C?
CMP C, C ;LARGER VALUE IN C?
*
JNC NFOUND ;JUMP IF LARGER VALUE NOT FOUND
*SNOC C, C ;LARGER VALUE NOT FOUND
JC NFOUND ;JUMP IF LARGER VALUE NOT FOUND
*E
```

ASM SCAN.ASM

Re-assemble, selecting source from disk A

hex to disk A

CP/M ASSEMBLER - VER 1.0

print to Z (selects no print file)

0122

002H USE FACTOR

END OF ASSEMBLY

DDT SCAN.HEX

Re-run debugger to check changes

15F DDT VER 1.0

NEXT PC

0121 0000

-L116

0116 JMP 0000 check to ensure end is still at 116H

0119 STAX B

011A NOP

011B INR B

- (rubout)

-G100.116 Go from beginning with breakpoint at end

\*0110 breakpoint reached  
 -0121 Look at "LARGE" correct value computed

0121 00 00 22 21 00 02 7E E6 77 13 23 E8 08 78 B1 " " 0 0 X  
 0130 C2 27 01 C3 03 23 00 00 00 00 00 00 00 00 00  
 0140 00 00 00 00 00 00 00 00 00 00 00 00 00 00

- (rubout) aborts long typeout

-00 stop DDT, debug session complete







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